Understanding how tertiary-level academic institutions create Entrepreneurial Engineers

Niyan Kwame Omari Fraser BSc. (Hons) (UWI); MSc. (JIBS)
Tasmanian School of Business & Economics

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Declaration of Originality

This thesis contains no material which has been accepted for a degree or diploma by the University or any other institution, except by way of background information and duly acknowledged in the thesis, and to the best of my knowledge and belief no material previously published or written by another person except where due acknowledgement is made in the text of the thesis, nor does the thesis contain any material that infringes copyright.

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Statement of Co-Authorship

The following people and institutions contributed to the publication of work undertaken as part of this thesis:

Author 1	Niyan K. O. Fraser	University of Tasmania
Author 2	Morgan P. Miles	Charles Sturt University
Author 3	Megan Woods	University of Tasmania
Author 4	Gemma K. Lewis	University of Tasmania

Paper 1
Located in Appendix Six

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Candidate was the primary author (author 1) and wrote the original version of the paper.

Candidate (author 1) and authors 2, 3, and 4 contributed to the development, editing, and formalisation of the final version of the paper.

- Author 1 contributed 70%
- Author 2 contributed 10%
- Author 3 contributed 10%
- Author 4 contributed 10%

We the undersigned agree with the above stated "proportion of work undertaken" for each of the above published (or submitted) peer-reviewed manuscripts contributing to this thesis:

Signed:

Niyan K.O. Fraser	Morgan P. Miles	Megan Woods	Gemma K. Lewis

Statement of Ethics

The research associated with this thesis was approved through the University of Tasmania's Social Sciences Human Research Ethics Committee (approval number H0014579).

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Abstract

World economies are demanding a new type of engineer – an Entrepreneurial Engineer – who possesses a multidisciplinary set of technical and entrepreneurial competencies. These new engineers are essential to the fostering of entrepreneurship, innovation, and technological enhancement within an economy. Given the importance of having entrepreneurial engineers, it is necessary for tertiary-level academic institutions to prepare their engineering students to undertake these roles. This is being done by offering entrepreneurship education to engineering students.

Despite the recognition of the importance of having and creating Entrepreneurial Engineers, very little research has examined how tertiary-level academic institutions educate engineering students about entrepreneurship. The only exception was the Standish-Kuon and Rice (2002) study, which examined the approaches taken by six academic institutions in the United States to educate engineering undergraduates about entrepreneurship. The findings from this study resulted in the emergence of a typology which presented three models to which entrepreneurship initiatives could be categorised into, and ultimately the three models that academic institutions could follow to educate their engineering students about entrepreneurship.

However, since the Standish-Kuon and Rice (2002) study was conducted, a number of developments in this area have occurred; including, for example, an evolution in entrepreneurship education approaches, a greater role played by external stakeholders and networks in the combination of engineering and entrepreneurship, and a greater presence of "university-wide" entrepreneurship education programmes. These developments necessitated a more contemporary investigation of the approaches used to educate engineering students about entrepreneurship in order to understand how educational institutions have responded to the changes that have occurred.

The overall aim of this study was to investigate how tertiary-level academic institutions educate engineering students about entrepreneurship. The typology developed by Standish-Kuon and Rice (2002) was used as the theoretical framework to understand and categorise the entrepreneurship initiatives analysed. For this study, all entrepreneurship education

initiatives for engineering undergraduates offered at academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States were examined. The decision to investigate entrepreneurship initiatives for engineering students outside the United States was made because these countries are all developed economies which rely heavily on engineering, and no research similar to that of Standish-Kuon and Rice (2002) had previously been conducted. The underlying objective was to determine whether the Standish-Kuon and Rice (2002) typology was still representative of present-day entrepreneurship initiatives used to educate engineering undergraduates, or if the typology had to be updated to reflect the changes that have occurred in this area.

This study used a mixed methods research methodology, with a multiphase sequential research design divided into three phases. Phase One was qualitative, with a desktop review performed on institution webpage descriptions of entrepreneurship initiatives for engineering undergraduates at 414 academic institutions in the United States. These initiatives were categorised according to the Standish-Kuon and Rice (2002) typology and changes were made where applicable. Phase Two was also qualitative, with a desktop review performed on institution webpage descriptions of entrepreneurship initiatives for engineering undergraduates at 13 institutions in Australia, 24 institutions in Canada, five institutions in New Zealand, and 36 institutions in the United Kingdom. These initiatives were categorised according to the typology identified during Phase One. Phase Three was quantitative, with data collected via an online questionnaire sent to engineering school administrators from 600 academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States. Completed surveys were received from 126 of the 600 institutions, which represented a 21% response rate.

The findings showed that the Standish-Kuon and Rice (2002) typology had to be updated and expanded to reflect present-day entrepreneurship initiatives for engineering students, proving that the typology was a valuable foundation for this research. Furthermore, the findings showed that today, a total of five models were used to categorise entrepreneurship initiatives for engineering undergraduates, and that academic institutions in the five countries use one (or in some cases more) of the five models to educate their engineering undergraduates about entrepreneurship. As a result, this thesis presents a new typology –

the Entrepreneurial Engineering Education (EEE) typology – that is used to categorise present-day entrepreneurship initiatives for engineering students, in addition to collective information regarding entrepreneurship initiatives for engineering students.

This research and its findings have implications for both theory and practice. From a theoretical perspective, the research contributes to gaining a more comprehensive understanding of how academic institutions use entrepreneurship to create Entrepreneurial Engineers, and presents the typology that describes how academic institutions are presently educating engineering students to be entrepreneurial. Furthermore, the research provides insight into the similarities and distinct differences that existed among the models of this typology. From a practical perspective, the findings show the models that academic institutions can use to create entrepreneurship initiatives for engineering students, and the models that represent the initiatives that are presently offered for engineering students. Furthermore, the findings provide insight into the models that are commonly used in specific countries.

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Chapter 1: Introduction

1.1: Introduction

A new engineer is in high demand. These engineers must maintain their traditional persona, in the sense of enabling the occurrence of technological advancement, but also possess a collection of non-technical attributes (Byers et al. 2013; Creed et al. 2002; Newport & Elms 1997; Tryggvason & Apelian 2006). Engineers today must be capable of, for example, identifying market-based opportunities (Elia et al. 2011), taking innovative approaches to problem-solving (Heinonen & Poikkijoki 2006; Ohland et al. 2004b), being flexible and coping with change (Heinonen & Poikkijoki 2006; Täks et al. 2014); taking risks (Kriewall & Mekemson 2010), working in teams (Goldberg 2006; Ohland et al. 2004a; Yurtseven 2002; Yuzuriha 1998); creating products and services that meet the needs of society (Kriewall & Mekemson 2010; Newport & Elms 1997), working in new work environments including large companies, small- and medium-sized enterprises, and new start-up ventures (Goldberg 2006), and developing new business ventures (Ochs et al. 2006).

With the continuous scientific and technological advancements that have occurred in today's global economy, it is particularly important that engineers foster the occurrence of entrepreneurship and innovation (Byers et al. 2013; Elia et al. 2011; Kriewall & Mekemson 2010; Lumsdaine & Binks 2003). This importance has been due to the emergence of opportunities and challenges that occur in world economies, especially given the fact that engineers must predict and invent the future by developing innovative technologies that address the needs of society (Byers et al. 2013; Elia et al. 2011). The new requirements of engineers can enable them to survive in an entrepreneurial environment, and as a result, it is important for the engineering education curriculum to create engineers with these multidisciplinary, entrepreneurial abilities (Byers et al. 2013; Kriewall & Mekemson 2010).

The need for the new engineer and the expansion of employment opportunities has resulted in a need for a change in the way engineering students are educated (Rau et al. 2004; Sunthonkanokpong 2011). As a result, there has been an increasing presence of entrepreneurship initiatives for engineering students, with entrepreneurship education being increasingly incorporated into the engineering curricula (Duval-Couetil et al. 2011, 2012; Luryi et al. 2007; Shartrand et al. 2008; Weaver & Rayess 2010). It is therefore important to understand how tertiary-level academic institutions use entrepreneurship education to create and develop entrepreneurial engineers. Standish-Kuon and Rice (2002) examined how universities in the United States educated engineering students about entrepreneurship and then developed a typology of models or approaches that were used to categorise the entrepreneurship education programmes that were created for engineering students. Therefore, using the Standish-Kuon and Rice (2002) typology as the research framework, the aim of this research study was to determine the models or approaches used by tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States to educate engineering students about entrepreneurship and ultimately create entrepreneurial engineers.

The first country selected for this research study was the United States. The United States is an innovation-driven economy characterised by a strong entrepreneurial ecosystem which enables entrepreneurial activity to occur (Regele & Neck 2012), as well as a world leader in entrepreneurship education (Gürol & Atsan 2006). The most important factor that made the United States essential to this research study was the fact that the original Standish-Kuon and Rice (2002) typology was created and developed using data collected from universities in the United States. Furthermore, U.S. engineering education has recognised the need for engineering students to additionally acquire the non-technical skills needed in the modern-day engineering environment, as evidenced by the reformation of the engineering programme accreditation criteria (EC2000) of the Accreditation Board for Engineering and Technology, Inc. (ABET), the board that accredits post-secondary education programs in the areas of applied science, computing, engineering, and engineering technology (Felder & Brent 2003; Prados et al. 2001; Shuman et al. 2005; Soundarajan 1999). The EC2000 criteria has resulted in institutions implementing programs that stimulate and develop entrepreneurial attributes and behaviours in engineering and science graduates in response to the demand for the new type of engineer (Dabbagh & Menascé 2006).

The decision was then made to investigate entrepreneurship initiatives for engineering students in Australia, Canada, New Zealand, and the United Kingdom. Like the United States, these four countries have innovation-driven economies and strong entrepreneurial ecosystems (Kelley et al. 2016). In the case of Australia, there has been an increase in entrepreneurship programmes (Kirby 2004), which could be the result of the importance of the small business sector to the national economy (Organisation for Economic Co-operation and Development (OECD) 2010). In Canada, engineers are increasingly seeking entrepreneurial opportunities (Solymossy & Gross 2015). In New Zealand, entrepreneurs play a significant role in the country's economic performance (Nel et al. 2008), with the country itself creating large numbers of entrepreneurs (Arthur et al. 2012). Finally, in the United Kingdom, there has been an increase in entrepreneurship education programmes (Kirby 2004), and entrepreneurship is promoted in order to stimulate innovation and promote economic growth (Lucas & Cooper 2006).

The objective of this chapter is to introduce the thesis. First, a discussion of the background to the research is presented, followed by a discussion of the research context. Next, an outline of the research opportunity, research objectives, and research questions in addition to the theoretical and practical contributions are discussed. A summary of the research study's methodology is then provided, and the chapter concludes with definitions of the important key terms, the delimitations of scope, and an outline of the structure of the thesis.

1.2: Background to the Research

1.2.1: The Importance of Engineering

Engineering is the use of science to enhance and make improvements in the lives of the people within a particular society (Ward & Angus 1996). It is about the knowledge that is required and the processes implemented to conceive, design, create, maintain, and later recycle or retire, something that is technical for a specific purpose (Malpas 2000). Overall, engineering essentially relates to the development, provision, and maintenance of any infrastructure, products, processes, or services that can be of value to the overall society (The U.K. Quality Assurance Agency for Higher Education (QAA) 2012). The engineering process is associated with the full life-cycle of a product, process or service, including the conception, the design and manufacture and any specific economic, legal, social, cultural, and environmental constraints (The U.K. Quality Assurance Agency for Higher Education

(QAA) 2012). Engineering therefore plays an important role, with the incorporation of science, technology, and innovation into economic development strategies allowing for the achievement of sustainable growth (Yackovlev & Scavarda 2010).

Societies gain great benefits from engineering (Parkinson 2010). In fact, engineering is the discipline that has had the greatest impact on society – it has generated several products that are used in modern day life including, for example, roads, aqueducts, electricity, communications, automobiles, modern bridges, and even weapons (Bugliarello 2010). Engineering leads to the creation of new products, and these new products help to improve the lives of a country's citizens through the generation of jobs, increase the financial success of engineering companies, and maintain a country's position in the world economy (Kriewall & Mekemson 2010). Therefore, engineering generates significant value by encouraging the growth and development of a country's economy, improving the life of the country's citizens, helping to position the country within the global economy, and serving to protect the environment (Marjoram & Zhong 2010).

As a profession, engineering enables the conversion of imagination and ideas into reality, and the presence of engineers allows for new solutions to be generated which improve the lives of many people (The U.S. National Academy of Engineering 2008). Engineers can be seen as problem-solvers, builders and adventures who aim to create technical artefacts and provide valuable services to society (Rochester 2002) by using existing, or new and innovative technologies to develop appropriate solutions to problems (Engineering Council 2010). As a result, engineering is a vital profession and the importance of having engineers is due to engineers' abilities to increase the level of productivity and stimulate the levels of innovation and technological advancement that can occur within an economy, which in turn, increase economic competitiveness and enhance overall standards of living (Eisenstein 2010). This demonstrates that engineering, through the actions of engineers, allows for the occurrence of innovation and research and development, which in turn, allows for problems to be addressed, high-tech jobs to be maintained, and new technologies and products to be created (Polczynski & Jaskolski 2005), and enables the generation of economic growth, competitiveness, and employment within a society (Wilson 2008).

1.2.2: The Changes in Engineering

Engineering, and the other fields of science, technology, and mathematics, are important to the development of knowledge within an economy (The U.S. National Academy of Engineering 2004). Traditionally, engineering was associated with technical problem-solving (Elia et al. 2011; Kriewall & Mekemson 2010), the determination of what was involved in product and service design and manufacturing, and subsequently how things were done (Polczynski & Jaskolski 2005), and the actual creation of products and processes (Kriewall & Mekemson 2010). This means that traditionally-trained engineers have specific characteristics. Previously, engineers were independent and self-sufficient inventors and highly motivated team members (Yurtseven 2002) who performed technical, routine tasks (Tryggvason & Apelian 2006). Because engineering focused solely on the acquisition of "left-brain" skills – technical and analytical skills that enabled the ability to think logically (Pistrui et al. 2011) – engineers were more structured, analytical and logical in their thinking (Herrmann 1996; Lumsdaine et al. 1999; Lumsdaine & Lumsdaine 1995). They were specialists who were involved in a narrow technical field and worked in large organisations (Goldberg 2006), and worked in solitude, focusing on what was happening in their immediate environment and reacting only when a problem arose (Ochs et al. 2001). In the past, engineers primarily operated in a minor capacity, where they facilitated technological change but bore no responsibility for any outcomes that stemmed from this change (Esbach 2009; Newport & Elms 1997).

Radical change has occurred within the global economy. It is now characterised by increased levels of competition (Hope & Hope 1997), advancement of information technology (Hope & Hope 1997; Luryi et al. 2007), new interdisciplinary fields (Luryi et al. 2007); global manufacturing and research and development activities (Luryi et al. 2007; Sunthonkanokpong 2011), and a changing job market (Duval-Couetil et al. 2015; Sunthonkanokpong 2011) with a shift in employment from large companies to smaller companies resulting from downsizing and start-ups (Creed et al. 2002; Luryi et al. 2007; Sunthonkanokpong 2011). The advances in technology and a new globalised world economy have made it necessary for companies to get closer to the customers, where they must respond quickly to customer needs and readily adapt to internal and external environment changes (Gündoğdu 2012).

The continuous evolution of the global market has resulted in changes occurring in the engineering field (Besterfield-Sacre et al. 2013; Kriewall & Mekemson 2010; Solymossy & Gross 2015; The U.S. National Academy of Engineering 2004). Engineering has evolved from a search for solutions to technical problems to the identification of opportunities in the market that have been driven by technological advancement (Byers et al. 2013; Elia et al. 2011; Kriewall & Mekemson 2010; Shartrand et al. 2010). Furthermore, the field of engineering has been characterised by emerging technologies, which are innovations that result in either the creation of new industries or the radical transformation of pre-existing ones (Day et al. 2000) and employment in both large organisations and small businesses and start-up environments (Benson et al. 2010; Creed et al. 2002; Luryi et al. 2007). Today, engineering is at the heart of market creation – it holds the responsibility for identifying unmet market needs, using high-technology-based designs to meet these market needs, and creating the relevant innovative products and processes (Kriewall & Mekemson 2010).

The depictions of present-day engineering have demonstrated that engineering is no longer restricted to a defined set of boundaries; it has become increasingly multidisciplinary mainly due to the increased complexity of the societal problems that need to be solved (Creed et al. 2002; Sunthonkanokpong 2011). As a result, engineers today must possess more and do more than they were required to in previous decades (Byers et al. 2013; Creed et al. 2002; Kriewall & Mekemson 2010; Pistrui et al. 2011; Sheppard et al. 2008; Täks et al. 2014; Weaver & Rayess 2010; Yurtseven 2002). The changes that have occurred within the global economy and the engineering discipline have therefore significantly influenced the traditional engineering career and ultimately the types of employment opportunities that are available to engineers (Creed et al. 2002; Lumsdaine 2001; Rahman et al. 2012). In simpler terms, the changes in engineering have resulted in a demand for a new engineer (Besterfield-Sacre et al. 2013; Creed et al. 2002; Lumsdaine 2001; Rahman et al. 2012). To meet the demand, it has become essential to learn about and understand the new engineer.

1.3: Research Context

1.3.1: The New Engineer

Engineers, as explained in section 1.2.2, were traditionally trained with left-brain skills and technical and engineering fundamentals that enabled them to be effective problem solvers. However, taking the state of today's global economy into consideration, being armed with technical knowledge and skills and being able to use these to solve problems is no longer enough (Pistrui et al. 2011). The world is becoming more dependent on technology, which, as a result, increases the need for engineers (Polczynski & Jaskolski 2005). With technological advancement mandating technical change and a resultant change in the engineering field, it is essential that engineers change in order to compete in the rapidly changing high-tech environment (Esbach 2009). Engineers have transitioned from being independent, self-sufficient and highly motivated inventors to becoming members of corporate world teams (Ohland et al. 2004b; Yurtseven 2002) which enables them to function in the modern-day multidisciplinary business environment (Fromm 2003; Wulf & Fisher 2002). Therefore, the new engineering environment requires an engineer who has a scientific and technical background coupled with non-technical knowledge and skills (Abdulwahed et al. 2013b; Byers et al. 2013; Creed et al. 2002; Duval-Couetil et al. 2015; Goldberg 2006; Newport & Elms 1997; Sheppard et al. 2008; Tryggvason & Apelian 2006). This is because engineers are the ones who must meet and anticipate future needs (Byers et al. 2013), be flexible and creative and able to recognise and take advantage of opportunities (Sheppard et al. 2008; The U.S. National Academy of Engineering 2004), and be analytical and able to solve the problems that affect society on a whole (Benson et al. 2010; Byers et al. 2013). This means that engineers must overall act to improve the quality of life (Benson et al. 2010; Byers et al. 2013).

The new abilities required of engineers mean that engineers must therefore be capable of working in new environments characterised by changing landscapes of markets, businesses, and society (Byers et al. 2013; Creed et al. 2002; Kriewall & Mekemson 2010). The traditional problem-solving role of the engineer still exists; however, it has expanded and evolved to include the capabilities that allow for the identification and creation of market-based opportunities derived from technology and scientific advancements (Elia et al. 2011;

Lumsdaine & Binks 2003; Polczynski & Jaskolski 2005; Weaver & Rayess 2010). This means that engineers must not only be technically creative, competent and opportunistic, but also possess the capabilities to assess risks (Lumsdaine 2001) and generate solutions to solve complex business problems (Kriewall & Mekemson 2010; Lumsdaine 2001; Täks et al. 2014). Furthermore, engineers today operate in a different employment environment where they work in a variety or large and small enterprises; which requires engineers to communicate within and across disciplines, be members of and collaborate on interdisciplinary teams, and work for a number of different clients (Byers et al. 2013; Duval-Couetil et al. 2015; Goldberg 2006; Kriewall & Mekemson 2010; Ohland et al. 2004b; Täks et al. 2014).

As a result, the new engineer must act in an entrepreneurial manner, leveraging both innovation and creativity in their approaches (D'Cruz et al. 2006; Kriewall & Mekemson 2010; Tabat 2010; Täks et al. 2014; Weaver & Rayess 2010). This means that it has become important to integrate entrepreneurship into the engineering field in order to address the needs of world societies and the global economy.

1.3.2: The Integration of Entrepreneurship into Engineering

Like engineering, entrepreneurship is extremely important to the global economy (Besterfield-Sacre et al. 2013; Bruyat & Julien 2001; Henry et al. 2003; Mäkimurto-Koivumaa et al. 2013). This is because entrepreneurship and its related activities have long been considered the primary driver of any given economy (Acs 1992; Alberti et al. 2004; Brock & Evans 1989; Bruyat & Julien 2001; Carree & Thurik 2003; Gürol & Atsan 2006; Kuratko 2005; Soundarajan et al. 2013). Entrepreneurship stimulates economic growth (Antonites & Nonyane-Mathebula 2012; Blenker et al. 2011; Duval-Couetil et al. 2015; Gerba 2012; Katz et al. 2014a; Kuratko & Hodgetts 2014; Mäkimurto-Koivumaa et al. 2013; Oosterbeek et al. 2010; Rasmussen & Sørheim 2006; Wilson 2008), stimulates a country's competitiveness in the global economy (Frazão et al. 2007; Kuratko & Hodgetts 2014; Regele & Neck 2012; Schaper & Volery 2004; Venkatachalam & Waqif 2005), and addresses employment issues that are faced by world economies (Azim & Al-Kahtani 2014; Karanassios et al. 2006; Lena & Wong 2003; Zampetakis et al. 2013) either through the creation and provision of jobs (Arthur et al. 2012; Bruyat & Julien 2001; Gerba 2012; Gürol & Atsan 2006; Richardson & Hynes 2008) or through individuals becoming self-employed (Frazão et al. 2007; Richardson

& Hynes 2008) via the creation of new business ventures which in turn create additional jobs (Aloulou & Fayolle 2005; Gerba 2012; Hisrich & O'Cinneide 1985; Rasmussen & Sørheim 2006). World economies are therefore characterised by higher levels of entrepreneurship (Richardson & Hynes 2008).

Engineering and Entrepreneurship are therefore both valuable fields. Engineers have been responsible for significant changes in the society, for example, the advancement of communications, infrastructure, manufacturing and health (Blue et al. 2005). Entrepreneurs on the other hand have been responsible for innovating, generating wealth, establishing new ventures, and creating new jobs (Lee et al. 2005; Lumsdaine & Binks 2003). Research has shown that the encouragement of both fields and having entrepreneurs and engineers in today's global economy are important to economic growth and overall development (Kriewall & Mekemson 2010; Lumsdaine & Binks 2003). This combination is beneficial – the higher the level of innovation and entrepreneurship incorporated into the engineering field, the more competitive an economy becomes (Scarlat 2007).

It's widely recognised that engineers are essential to the driving of technological innovation and the creation of new ventures (Fayolle et al. 2005; Ulijn & Fayolle 2004), and this indicates that entrepreneurship forms the foundation for the occurrence of technological innovations and firm renewal (Menzel et al. 2007). Entrepreneurship and innovation are at opposite ends of the innovation process – innovation is the input which produces an invention or a new product or process development, while entrepreneurship is the outcome of the innovation which results in either new business creation or existing business growth (Duval-Couetil & Dyrenfurth 2012). Being innovative is therefore an important characteristic of the entrepreneurial persona (Entrialgo et al. 2000; Stewart et al. 2003; Thomas & Mueller 2000; Utsch & Rauch 2000). To drive innovation, engineers must be technically competent, have entrepreneurial mindsets, and possess a complementary set of personal and professional competencies (Menzel et al. 2007; Pistrui et al. 2011). Engineers must also launch entrepreneurial start-ups (Duval-Couetil et al. 2011), which are essential to innovation, productivity, and effective competition (Plaschka & Welsch 1990), can result in technological advancement and growth (Elmuti et al. 2012), stimulate change and competition (Elmuti et al. 2012), and allow individuals the opportunity to achieve success (Kuratko & Hodgetts 2014).

The new engineering environment has led to the emergence of Entrepreneurial Engineering and Entrepreneurial Engineers. Entrepreneurial Engineering is the use of entrepreneurial attributes to focus on technology-based opportunities which enable the emergence of new employment opportunities and the transformation of technology into new products and services (Polczynski & Jaskolski 2005). Entrepreneurial Engineers are therefore individuals who create these employment opportunities and new products and services due to their possession of a strong, technical, science, and engineering background, an entrepreneurial mindset, and entrepreneurial knowledge and skills (Duval-Couetil et al. 2015). The importance of having Entrepreneurial Engineers has therefore made it essential for a deeper understanding of how to develop this new type of engineer.

1.4: Research Opportunity, Research Objectives, and Research Questions

A number of research opportunities exist in relation to developing a greater understanding of Entrepreneurial Engineering and Entrepreneurial Engineers. Previous research studies in an Entrepreneurial Engineering context have focused on, for example, defining what Entrepreneurial Engineers are and how they are distinguished from traditional engineers (Duval-Couetil et al. 2012; Lumsdaine & Binks 2003), what Entrepreneurial Engineers must possess to be functional and successful (Kriewall & Mekemson 2010), the types of entrepreneurship initiatives offered by tertiary-level academic institutions for engineering students (Byers et al. 2013), and the need and justification for entrepreneurship education to be integrated into the engineering curriculum (Duval-Couetil et al. 2012). Developing a deeper understanding of entrepreneurship education and, in this context, how entrepreneurship education can be used to create Entrepreneurial Engineers, may potentially encourage the further development of entrepreneurship initiatives for engineering students and therefore encourage the occurrence of Entrepreneurial Engineering activity in different world economies. Research into how entrepreneurship education was used to create Entrepreneurial Engineers has previously been done. A study conducted by Standish-Kuon and Rice (2002) sought to examine six technological entrepreneurship initiatives for engineering students in academic institutions in the United

States. From data collected in 1997, the researchers developed a typology which presented three models. These models helped to understand how these academic institutions were educating engineering students about entrepreneurship and thereby creating Entrepreneurial Engineers. The changes in the availability of entrepreneurship education and the increased demand have therefore made it necessary to revisit the typology to gain a present-day understanding.

Using the Standish-Kuon and Rice (2002) typology, which was developed based on data collected from entrepreneurship initiatives at six universities in the United States, this PhD research study sought to examine how tertiary-level academic institutions in the United States, as well as Australia, Canada, New Zealand, and the United Kingdom are using entrepreneurship education to create engineers with entrepreneurial abilities. An extensive literature review has revealed that the Standish-Kuon and Rice (2002) typology is the only typology in existence that shows how academic institutions educate engineering students about entrepreneurship, and has been accepted and used in previous research studies. Furthermore, there was no evidence from the literature reviewed of a similar typology created and developed based on non-U.S. entrepreneurship initiatives, or the use of this typology to examine entrepreneurship initiatives for engineering students in countries other than the United States.

The literature reviewed has presented a strong demand for Entrepreneurial Engineers. Given this demand, plus the increasing presence of entrepreneurship initiatives for engineering students in different countries, and the importance of creating and developing entrepreneurship educational initiatives for engineering students, it became necessary to revisit the Standish-Kuon and Rice (2002) typology in order to develop a deeper understanding of the role played by tertiary-level academic institutions in the creation of entrepreneurial individuals. The Standish-Kuon and Rice (2002) typology was developed based on data collected in 1997, and in fact, by the end of the study, two of the six universities examined were already evolving from one model to another. By revisiting this typology, it was possible to first, determine if the typology was still representative of the present-day models or approaches used by tertiary-level academic institutions to educate engineering students about entrepreneurship, and second, determine whether the typology could be used to categorise present-day entrepreneurship education initiatives that have been created and developed for engineering students.

As a result, the aim of this PhD research study was to determine the models or approaches used by tertiary-level academic institutions to create and develop Entrepreneurial Engineers through entrepreneurship education. To extend the model and determine its relevance outside the United States, the decision was made to examine entrepreneurship education initiatives from academic institutions in five countries – Australia, Canada, New Zealand, the United Kingdom, and the United States. The study had three research objectives:

- To identify how tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States have addressed the need for engineering undergraduate students to develop entrepreneurial abilities;
- To determine the typology developed based on the methods and approaches implemented and used by tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States to educate their engineering undergraduate students about entrepreneurship;
- To determine the parameters and limitations of the proposed typology in terms of the typology's suitability for the classification of entrepreneurship initiatives used to create Entrepreneurial Engineers.

As previously stated, the decision was made to examine the entrepreneurship initiatives in multiple countries. Entrepreneurship education is available in various countries around the world, and similarity has been identified in the content of these entrepreneurship education programmes (Katz 2008). Despite this, it is important than entrepreneurship education should be customised according to the national and cultural context of the country within which it is present (Giacomin et al. 2011; Lee et al. 2006; Pittaway & Cope 2007). Regional differences have been identified in the literature – for example, in Australia, foundations of entrepreneurship and business planning courses are used to teach students about entrepreneurship (Crispin et al. 2013); in Europe, stand-alone courses, that are primarily optional, are used (Fayolle 2009); and in the United States, students primarily learn about entrepreneurship through minor and certificate programmes added to their degrees (Byers et al. 2013). These regional differences demonstrate the problems with the potential for global standardisation of entrepreneurship education initiatives (Katz et al. 2014a). As a result, although an initiative achieves success in one environment, it may not succeed in another (Nel et al. 2008). Awareness of regional differences can help to determine how entrepreneurship education initiatives are structured, and help to create and develop future initiatives to maximise the possibility for successful outcomes.

In order to address the research opportunity and aim, three research questions were posed in the research study. The Entrepreneurial Engineering literature reviewed – for example Byers et al. (2013); Kriewall and Mekemson (2010); Duval-Couetil et al. (2015); Duval-Couetil et al. (2010b, 2012) – has highlighted the importance of having Entrepreneurial Engineers and the role that entrepreneurship education can play in preparing engineering students to be entrepreneurial. Therefore, the first question focused on the measures that have been taken by tertiary-level academic institutions to ensure that their engineering undergraduates develop entrepreneurial abilities:

Research Question #1*: How have tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States addressed the need for engineering undergraduates to develop entrepreneurial abilities?*

Based on data collected from entrepreneurship education programmes for engineering students at six universities in the United States, the Standish-Kuon and Rice (2002) study determined that a typology consisting of three models/approaches – the *Business School* model, the *Engineering School* model, and the *Multi-School* model – presented the models or approaches that were used by tertiary-level academic institutions to educate their engineering students about entrepreneurship. This presented the methods and approaches used by these institutions to facilitate the teaching of entrepreneurship to engineering students. Taking the typology and methods and approaches into consideration, the second question focused on the identification of the typology, resulting from the methods and approaches, that has been implemented and used by tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States, to educate their engineering undergraduates about entrepreneurship:

Research Question #2*: What is the typology, resulting from the methods and approaches, which has been implemented and used by tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States to educate their engineering undergraduates about entrepreneurship?*

In order to assess the strength of the typology identified and determine if the typology is suitable for classifying the models or approaches used by tertiary-level academic institutions to educate engineering students about entrepreneurship, Hunt's (1976, 2010) criteria for acceptable classification schemata was selected. Classification schemata is a way of organising phenomena into classes or groups that open the possibilities for investigation and theory development to occur (Hunt 1976, 2010). The decision to use the Hunt (1976, 2010) criteria was made based on the recognition, acceptance, and use of this criteria over the last four decades. These criteria have been used to evaluate typologies in a number of different research studies (see, for example, Cunningham et al. (2009); Cunningham et al. (2008); Greig (2003); Hassanien and Dale (2011)). Therefore, using Hunt's (1976, 2010) criteria, the third question addressed the suitability of the typology of models or approaches, identified, in the second research question, in the classification of entrepreneurship initiatives for engineering undergraduates, and therefore the parameters and limitations that are associated with the typology:

Research Question #3*: What are the parameters and limitations associated with the proposed typology with respect to its suitability for the classification of entrepreneurship education initiatives used to create Entrepreneurial Engineers?*

The research findings provided insight into how tertiary-level academic institutions are educating engineering students about entrepreneurship, and subsequently, how these institutions create Entrepreneurial Engineers. As an extension, the findings also determine whether or not the Standish-Kuon and Rice (2002) typology represented present-day entrepreneurship initiatives for engineering students both within and outside the United States.

1.5: Contribution of the Research

Undertaking this research study can serve to develop research in Entrepreneurial Engineering and provide greater insight to the role that education can play in creating Entrepreneurial Engineers. It can provide insight into the educational approaches that are presently being used to create Entrepreneurial Engineers and also provide information about how these approaches compare to each other. This research study makes a number of different theoretical and practical contributions. From a theoretical perspective, this research contributed to a deeper understanding of how tertiary-level academic institutions use entrepreneurship education to create Entrepreneurial Engineers. Stemming from this, this research allowed for an investigation into whether the Standish-Kuon and Rice (2002) typology can be used to categorise entrepreneurship initiatives that have been developed for, and offered to, engineering students today, and if not, the changes that need to be made to the typology in order for it to be representative of present-day entrepreneurship initiatives for engineering students. Furthermore, the research provided insight into the similarities and distinct differences that existed among the models or approaches of the typology.

From a practical perspective, the research findings provided insight into the range of models or approaches that can be used to educate engineering students about entrepreneurship. This is important for administrators at tertiary-level academic institutions for two reasons. Firstly, the findings will allow administrators of these institutions to identify the models or approaches that their entrepreneurship initiatives for engineering students follow. Secondly, the findings will provide administrators and educators, who are seeking to integrate engineering and entrepreneurship, with a blueprint that could be used to create and develop entrepreneurship initiatives for engineering students. Insight into the available models or approaches can allow academic institutions to identify the ones that are most commonly used in their countries, based on the educational system and what students are demanding, in order to know which model or approach to select. It can also be used as a means of distinguishing an academic institution from its competitors, where institutions select models or approaches that are different from others in their respective countries.

The findings from this PhD research study with therefore have implications for educational theory, policy and practice in the area of entrepreneurship education.

1.6: Methodology

To address the three research questions that were stated in section 1.4, this PhD research study, which possessed both exploratory and descriptive characteristics, adopted a deductive approach – it drew upon an existing typology in order to examine entrepreneurship initiatives for engineering undergraduates. A mixed methods approach was utilised in order to present an overall picture of these models. To obtain this picture, the research study adopted a multiphase research design consisting of three phases. In the first two phases, which were qualitative, data was collected from the academic institutions' webpages and analysed using both manual content analysis (Phase One) and computer content analysis (Phase Two) methods. In the third phase, which was quantitative, data was collected using an online questionnaire and analysed using statistical computer software.

1.7: Terminology and Definitions

Table 1 presents the terminology and definitions that were used in this research study and adopted throughout the thesis. In some cases, the five countries used different terminology to refer to educational concepts. As a result, Table 1 has been developed to clarify the terms that were used in this research study, and show how these terms were used.

Table 1: The terminology and definitions used in this PhD research study

Terminology and Definitions	
Terminology	**Definitions**
Academic Year	The period of time during which classes are taught. The academic year is generally divided into terms of varying lengths, such as semesters, trimesters, or quarters. This period usually runs, for example, from September to May in North America and the U.K., and a 12 month period beginning in January in Australia and New Zealand.
Bachelor's Degree	An undergraduate degree awarded upon completion of approximately three or four years of full-time study (or longer if part-time study is taken).

Co-curricular Activities	Activities, programs, and learning experiences that complement, in some way, what students are learning in their academic programs and courses; i.e., experiences that are connected to or mirror the academic curriculum.
College (1)	A postsecondary/tertiary-level institution that provides an undergraduate education and, in some cases, masters and doctorate degrees.
College (2)	An academic subdivision of a university which is typically comprised of different departments (another term used for faculty or school); for example, the College of Business.
***Note**: Both definitions of "College" were used in this research study. For the first definition, some of the U.S. tertiary-level academic institutions reviewed were considered colleges, as outlined in the first definition. In the case of the second definition, many of the universities reviewed were divided into academic colleges (for example, the College of Engineering). It was therefore essential to use both definitions of "College" in this research study.*	
Core Course	Courses that provide the foundation of the degree program and are required of all students seeking that degree.
Course	Regularly scheduled class sessions of one to five hours (or more) per week during a semester or term. A degree program is made up of a specified number of required and elective courses and varies from institution to institution.
Degree	Diploma or title conferred by a college, university, or professional school upon completion of a prescribed program of studies.
Department	Administrative subdivision of a school, college, or university through which instruction in a certain field of a study is given; for example, the History Department.
Double/Dual/Combined/Joint Degree	Bachelor's degree where students study two different areas; for example a degree in Business and Engineering.
Electives	Courses that may be chosen from any field of study. Electives give students an opportunity to explore other topics or subjects of interest.
Entrepreneurship Initiative (University-based)	Courses and co-curricular/extra-curricular activities that teach, for example, entrepreneurial management, strategy, innovation, and venture development in a university setting.
Extra-curricular Activities	Non-academic activities undertaken outside university courses.
Faculty (1)	People who teach courses at colleges and universities. Faculty members may include professors, associate professors, and instructors.

Faculty (2)	An academic subdivision of a university which is typically composed of different departments (another term used for college or school); for example, Faculty of Engineering.
***<u>Note</u>**: Both definitions of "Faculty" were used in this research study. The first definition was used to describe the people who taught the entrepreneurship courses. The second definition was used as an alternative to the second definition of "College". Some of the universities reviewed was subdivided into faculties (for example, the Faculty of Engineering). It was therefore essential to use both definitions of "Faculty" in this research study.*	
Graduate	A student who has completed a course of study at the university or college level.
Institute	A post-secondary/tertiary-level institution that specialises in degree programs in a group of closely related subjects; for example, Institute of Technology.
Major	The student's field of concentration. Major courses represent 25-50% of the total number of courses required to complete a degree. Most students pursue one major, but some pursue double majors (two fields of concentration).
Minor	The student's secondary field of concentration. Students who decide to pursue a minor will usually complete about five courses in this second field of study.
School (1)	A term used in place of the words "college", "university", or "institution", or as a general term for any place of education; for example Law School.
School (2)	An academic subdivision of a university which is typically comprised of different departments (another term used for a college or faculty); for example the School of Architecture.
***<u>Note</u>**: Both definitions of "School" were used in this research study. For the first definition, some of the U.S. tertiary-level academic institutions reviewed were referred to as schools instead of colleges or universities. In the case of the second definition, many of the universities reviewed were divided into academic schools (for example, the School of Engineering). It was therefore essential to use both definitions of "School" in this research study.*	
Semester	A period of study lasting approximately 15 to 16 weeks or one half of the academic year.
Subject	Course in an academic discipline offered as part of a curriculum of an institution of higher learning.
Undergraduate (level)	Undergraduate programs including those leading to a bachelor's or first professional degree as well as to diplomas and certificates below degree level.

University	A post-secondary/tertiary-level institution that offers both undergraduate and graduate degree programs.

1.8: Delimitations of Scope

The delimitation associated with this PhD research study was that the type of entrepreneurship initiatives reviewed were those offered at the undergraduate or bachelor degree level. Entrepreneurship has been one of the fastest growing areas at the undergraduate level in a variety of academic disciplines with larger number of programmes being provided (Brooks et al. 2007). This has occurred based on the fact that students experience a higher level of intention towards entrepreneurial careers the earlier they are introduced to entrepreneurship and innovation (Wilson 2008). Introducing entrepreneurship to engineering students at the undergraduate level allows for entrepreneurship to be experienced and learned during a developmental time in students' engineering education (Polczynski & Jaskolski 2005). Given the importance of entrepreneurship education for engineering students, especially at the undergraduate level, it is valuable to gain insight into entrepreneurship education for engineering students. The focus was therefore placed on the undergraduate entrepreneurship initiatives for engineering students, with graduate entrepreneurship initiatives for engineering students being excluded.

1.9: Thesis Structure

This doctoral thesis is comprised of a total of seven chapters. In this chapter (Chapter 1), the Introduction chapter, the purpose of the research study was introduced. It commenced with the background to the research, where insight into the importance of engineering to world societies and the change that has occurred in the field of engineering was presented. This was then followed by the research context, with discussions of the new type of engineer that is required due to the evolved engineering field and how entrepreneurship has been integrated into today's evolved engineering field presented. The chapter continued with a discussion of the research opportunity and justification for the research, and a statement of the three specific research questions. Also included in this chapter were overviews of the methodology that was used in the research project, the definitions and terminology used, and the overall thesis structure.

Chapters 2 and 3 present detailed reviews of the literature associated with the research area being investigated. Chapter 2 presents a picture of Entrepreneurial Engineering and the associated Entrepreneurial Engineers. The chapter commences with definitions of Entrepreneurial Engineering as well as Entrepreneurial Engineers. It then continues with a discussion of the characteristics of the Entrepreneurial Engineers, more specifically, discussions of the entrepreneurial mindset, competencies, knowledge, and skills that Entrepreneurial Engineers require, and the capabilities that they must demonstrate. The chapter concludes with a discussion of the four roles that Entrepreneurial Engineers must be able to occupy: engineer, intrapreneur, entrepreneur, and social entrepreneur.

Chapter 3 continues the literature review with the focus being placed on the creation of Entrepreneurial Engineers. The chapter commences with a discussion of how entrepreneurial graduates (in any discipline) are created, including the role played by tertiary-level academic institutions in educating students about entrepreneurship, and then discusses the changes that have occurred in entrepreneurship education and the structure of entrepreneurship education. The chapter then continues with a discussion on how Entrepreneurial Engineering graduates are created. First, there are discussions of the changes that have occurred in engineering education, the response of tertiary-level academic institutions to the need for Entrepreneurial Engineers and the entrepreneurial initiatives that have been designed for engineering students. Next, the Standish-Kuon and Rice (2002) typology of the models or approaches used to educate engineering students about entrepreneurship is presented. The chapter concludes with a presentation of the gap in the literature and an overview of the resultant doctoral research study, including the research objectives and questions.

Chapter 4 provides a description of the methodology used in this research project. This chapter begins with a discussion of the selected philosophical framework and the research approach. These are then followed by a presentation of the research design, including an explanation of how the research design was generated, and a description of, and justification for, the design selected. It then continues with a discussion of each of the phases, including the sample determined and the methods used for data collection and analysis. A brief discussion of data quality and explanation of the research project's ethical considerations are provided at the conclusion of this chapter.

Chapters 5 and 6 present the findings obtained from the analysis of the data. The findings were divided into two groups. Chapter 5 represents the first group of findings, and discuses overall findings related to entrepreneurship education for engineering undergraduates. Chapter 6 presents the second group of findings and presents the new typology that describes how tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States educate their engineering undergraduates about entrepreneurship. This chapter also presents descriptions of the components of each of the models and concludes with a discussion of the characteristics that help to distinguish among the models.

The final two chapters conclude the PhD thesis. Chapter 7 provides a discussion of the research findings in accordance with an assessment of the new typology based on Hunt's (1976, 2010) acceptable classification schemata. It concludes with a discussion about the typology and its suitability for describing how tertiary-level academic institutions educate engineering undergraduates about entrepreneurship. Chapter 8 completes the PhD thesis with a summary of the research findings, the strengths and limitations of the research, and suggestions for future research.

Chapter 2: Literature Review Part I

2.1: Introduction

Chapter 2 commences with a description of what is meant by Entrepreneurial Engineering and Entrepreneurial Engineers. It then continues with a presentation of the characteristics of the Entrepreneurial Engineer, concluding with a discussion of the roles that the Entrepreneurial Engineer must be capable of occupying.

2.2: Understanding Entrepreneurial Engineering and Entrepreneurial Engineers

Entrepreneurial Engineering, as demonstrated in the literature reviewed, is an evolved form of engineering with entrepreneurial characteristics. Simultaneously, Entrepreneurial Engineering is seen as a subset of entrepreneurship (Polczynski & Jaskolski 2005). Entrepreneurship is about searching for, identifying, and developing opportunities, and then exploiting the opportunities either in the form of new firm creation or within existing organisations (Shane & Venkataraman 2000). It exists in different forms. Entrepreneurship can first be viewed as the entrepreneurial efforts of individuals external to existing organisations (Gündoğdu 2012). In this context, it refers to the identification, analysis, and taking advantage of opportunities that create value by taking risks, coping with uncertainty and uncertain situations, organising resources without regard to the location of the entrepreneur, and seeing ideas through to completion (Carlsson et al. 2013; Churchill 1992; Gibb 2002; Kuratko 2005; Mäkimurto-Koivumaa et al. 2013). The purpose of entrepreneurship is to stimulate economic activity (Besterfield-Sacre et al. 2013; Blenker et al. 2011; Gallant et al. 2010; Gerba 2012; Gürol & Atsan 2006; Kuratko 2005; Mäkimurto-Koivumaa et al. 2013; Soundarajan et al. 2013), and to generate wealth and add value to society (Elia et al. 2011; Lumpkin & Dess 1996). Entrepreneurship can also include the creation of a new business venture, given that the creation process requires important structural and strategic decisions (Cooper 1981; Kuratko & Hodgetts 2014).

Entrepreneurship can also occur within existing organisations, with entrepreneurial activities occurring within an existing organisation being referred to as Intrapreneurship (Antoncic & Hisrich 2003; Sharma & Chrisman 1999). It involves the initiatives that are taken by employees to undertake innovation in the form of new or renewal activities (Bosma et al.

2010; Kuratko et al. 1990; Stevenson & Jarillo 1990). These new or renewal activities can be include the creation of new products, services, and markets for employers (Maier & Pop Zenovia 2011). Intrapreneurship can also involve the exploitation of opportunities in the form of creating new organisations or ventures in association with an established organisation (Haskins & Williams 1987).

Besides the creation of profit and generation of wealth, entrepreneurship can also be used to create positive social impact and ensure financial sustainability; this is referred to as Social Entrepreneurship (Agrawal & Hockerts 2013). Social Entrepreneurship is about the creation of social value in lieu of personal or shareholder wealth (Zadek & Thake 1997), with a focus on innovation activity and the creation of something new as opposed to the reproduction of existing practices or companies (Austin et al. 2006). In defining Social Entrepreneurship, the important element that emerges is the solving of problems and the associated emphasis placed on the creation and development of initiatives that result in new social outcomes or impacts (Johnson 2000). Furthermore, Social Entrepreneurship can result in the creation of new social enterprises and not-for-profit organisations, as well as continuous renewal and innovation activities in existing organisations (Sullivan Mort et al. 2003). Overall, Social Entrepreneurship is about the discovery and exploitation of opportunities that create social and/or environmental benefits (Hockerts 2007, 2010). This entails social innovation (Austin et al. 2006), social change (Light 2006), social problem-solving (Bornstein & Davis 2010), and the creation of social value (Dees 1998).

Entrepreneurial Engineering incorporates elements of Entrepreneurship, Intrapreneurship, and Social Entrepreneurship. Entrepreneurial Engineering, which is also referred to as Technology Entrepreneurship (Bailetti 2012), Engineering Entrepreneurship (Esbach 2009), or Technopreneurship (Lumsdaine & Binks 2003), can be defined as the transfer of technology into commercially viable products and services that are developed in response to customer need, and which enable the sustainable competitive advantage in the global marketplace (Bailetti 2012; Elia et al. 2011; Esbach 2009). It can be seen as a process that incorporates the skills and knowledge needed for successful entrepreneurship, a focus on technology-based opportunities which help to create and maintain attractive, valuable, employment prospects, and learning how to deal with identifying, acquiring, developing, and transferring technology into new products and services (Polczynski & Jaskolski 2005). Unlike other forms of entrepreneurship, the focus of Entrepreneurial Engineering is on collaborative experimentation and the production of new products, assets, and their attributes, all of which are related to scientific and technological advancement (Bailetti 2012). Therefore, Entrepreneurial Engineering allows for the use of innovation and the design and creation of products and processes that stimulate cash flow, revenue and profits for the enterprising organisation (Kriewall & Mekemson 2010), and to address social problems faced in a consistently evolving environment (Esbach 2009).

Entrepreneurial Engineering requires a combination of technical knowledge and capabilities, and the ability to take advantage of business opportunities, with the focus being placed on entrepreneurship as well as traditional technical knowledge and skills (Elia et al. 2011). This means that not only are technical knowledge and skills required, but entrepreneurship skills, business skills (for example, marketing and finance), creativity, strategic thinking, and innovation are also needed for the opportunities to be fully exploited (Lumsdaine & Binks 2003). The combination of technical and entrepreneurial knowledge and skills has enabled engineering to evolve from the generation of solutions focused on how to do something to the generation of creative solutions that address the issue of what to do (Polczynski & Jaskolski 2005).

Entrepreneurial Engineering demonstrated the need for an Entrepreneurial Engineer – one who has the traditional technical and scientific background of engineers as well as the global vision, creativity, imagination, and business and managerial skills possessed by entrepreneurs (Tryggvason & Apelian 2006). Therefore, the Entrepreneurial Engineer – also referred to as an Entrepreneurially-oriented engineer (Antonites & Nonyane-Mathebula 2012), Entrepreneurially-minded engineer (Kriewall & Mekemson 2010; Tabat 2010), Technopreneur (Lumsdaine & Binks 2003), Effective engineer (Newport & Elms 1997), Enterprising engineer (Tryggvason & Apelian 2006), or Engineering Entrepreneur (Nichols & Armstrong 2003) – is an engineer, or an entrepreneur, who possesses a strong, technical, science, and engineering background, an entrepreneurial mindset, and entrepreneurial knowledge and skills (Duval-Couetil et al. 2015).

Entrepreneurial Engineers share a number of similarities with traditional engineers as they must demonstrate traditional engineering thoughts and actions (Kern Entrepreneurship Education Network (KEEN) 2014; Lumsdaine & Binks 2003). However, the possession of an entrepreneurial mindset and entrepreneurial characteristics provides Entrepreneurial Engineers with a number of important capabilities. They are able to communicate, share, and promote their ideas while managing themselves and others (Goldberg 2006). They can take into consideration the benefits that new products can provide for end-users and make use of innovation to obtain the most efficient use of technology to meet customer needs in order to stimulate demand and generate revenue and profits (Kriewall & Mekemson 2010). They can organise, manage, and assume the risks associated with operating an engineering business enterprise (Nichols & Armstrong 2003). They are also able to apply technical knowledge and skills in order to contribute to innovation (Antonites & Nonyane-Mathebula 2012), and use entrepreneurship to encourage and develop economic growth (Antonites & Nonyane-Mathebula 2012). This shows that Entrepreneurial Engineers need to work on problems that they are asked to address as well as be able to define the problems that they or their companies should be solving (Tabat 2010). Entrepreneurial Engineers must therefore be able to identify opportunities, understand market forces, and successfully commercialise new technologies (Shartrand et al. 2008).

In summary, an Entrepreneurial Engineer is an engineer who:

- possesses a scientific and mathematical background;
- knows how to use and evaluate acquired information transforming it into knowledge;
- make use of engineering fundamentals in order to assess what can be done and acquire the tools to ensure it is done effectively;
- has the necessary team and communication skills coupled with an understanding of global and current issues in order to work effectively with others;
- possesses an entrepreneurial spirit coupled with managerial skills, creativity, imagination; and
- possesses a vision which allows engineers to identify needs and generate and execute potential solutions (Tryggvason & Apelian 2006).

2.3: Characteristics of Entrepreneurial Engineers

Entrepreneurial Engineers must be capable of doing certain activities. They must be able to recognises, assess, and pursue technological opportunities, either in start-up environments or existing companies (Goldberg 2006). They must also be able to generate valuable business opportunities and identify potential opportunities that may arise in the market (Polczynski & Jaskolski 2005). In generating solutions, Entrepreneurial Engineers have to view problems as opportunities, and strive to use both historical as well as new, innovative means to solve them (Byers et al. 2013). Pursuing opportunities requires Entrepreneurial Engineers to be innovative, where they hold the responsibility for technological advancement and change (Weaver & Rayess 2010). Entrepreneurial Engineers use technology to design, create, develop, and test products that can meet the needs of consumers and be commercialised (Kriewall & Mekemson 2010; Polczynski & Jaskolski 2005). This provides opportunities for Entrepreneurial Engineers to "invent the future" through the development of technologies that solve global problems and enhance the quality of life (Byers et al. 2013). It is also important that Entrepreneurial Engineers take present and future societies into consideration by demonstrating social consciousness and cultural and environmental awareness (Newport & Elms 1997; Torres et al. 1997). This requires Entrepreneurial Engineers to act by determining the suitability of ideas in a societal context (Kriewall & Mekemson 2010). In order for Entrepreneurial Engineers to carry out these activities, it is important that they possess certain characteristics. As a result, research has been undertaken into determining the characteristics that are required by Entrepreneurial Engineers.

One of the characteristics addressed in research on Entrepreneurial Engineers has been personal traits or attributes. Entrepreneurial Engineers are perceived to possess a variety of personal traits. Examples of these traits include optimism (Kriewall & Mekemson 2010), intuition (Beattie 2000; Newport & Elms 1997), ambition (Newport & Elms 1997), motivation (Newport & Elms 1997; Zappe et al. 2013), strength (Sundar & Madhavan 2013), good judgement (Beattie 2000; Newport & Elms 1997), clear thinking (Beattie 2000; Newport & Elms 1997), energy (Newport & Elms 1997), inspiration (Beattie 2000), ethics (Kriewall & Mekemson 2010), and a passion for engineering (Goldberg 2006; Kriewall &

Mekemson 2010; Newport & Elms 1997; Zappe et al. 2013). In previous research conducted in entrepreneurship the issue about whether or not specific traits were required for individuals to be entrepreneurial returned to the issue of whether or not entrepreneurship can be taught and therefore whether entrepreneurs are made or born (Fiet 2000b; Henry et al. 2005a, 2005b; Klein & Bullock 2006). This discussion ended with the acceptance that entrepreneurship can be taught and as a result this discussion is now obsolete (Kuratko 2005), thereby demonstrating that individuals do not require specific personal traits in order to become an entrepreneur. Furthermore, although it has been recognised that the potential exists for traits to be affected by entrepreneurship education, it is generally perceived that traits do not change over time and therefore are not directly influenced by participating in an entrepreneurship programme (Oosterbeek et al. 2010). As a result, this section of Chapter Two will not discuss traits. Instead, it will focus on the characteristics of Entrepreneurial Engineers which can be developed through entrepreneurship education. Much research has been done on what characteristics engineers must possess in order to have an entrepreneurial persona and be distinguished from traditional engineers. Exhibiting entrepreneurial characteristics means demonstrating that Entrepreneurial Engineers possess attributes associated with wealth-generating and socially-oriented entrepreneurship. A discussion of the entrepreneurial mindset, competencies, and knowledge and skills associated with Entrepreneurial Engineers will therefore be presented in this section.

2.3.1: The Entrepreneurial Mindset

In order for engineers to be in an entrepreneurial frame of mind and possess the attitude which allows for entrepreneurial behaviour to be exhibited, entrepreneurial actions to be carried out, and creativity and innovation to occur, it is important that they possess an Entrepreneurial mindset (Kriewall & Mekemson 2010; Täks et al. 2014; Weaver & Rayess 2010), the ability to take risks, and overall, an entrepreneurial drive (Zappe et al. 2013). The Entrepreneurial mindset is an individual's ability to be dynamic, flexible, and self-regulating in his or her cognitions in given dynamic and uncertain task environments (Haynie et al. 2010; Heinonen & Poikkijoki 2006). It is comprised of an individual's attitude and the entrepreneurial behaviour that is demonstrated through his or her action (Mäkimurto-

Koivumaa et al. 2013). Research into the Entrepreneurial mindset, was conducted by McGrath and MacMillan (2000). The researchers explained that the Entrepreneurial mindset consists of five defining characteristics: the seeking of opportunities, the pursuit of opportunities, the pursuit of the best opportunities, the execution of these opportunities, and the engagement of relevant individuals (McGrath & MacMillan 2000).

The first characteristic of the entrepreneurial mindset is the seeking of opportunities – entrepreneurial individuals must seek new opportunities with vigour and passion (McGrath & MacMillan 2000). Possessing an entrepreneurial mindset means that entrepreneurial individuals must be and remain alert in order to identify ways in which they could deviate from the norm when it comes to the way business is undertaken, and create an economic profit (McGrath & MacMillan 2000). The second characteristic of the entrepreneurial mindset is the pursuit of opportunities – entrepreneurial individuals must pursue opportunities with enormous discipline (McGrath & MacMillan 2000). Once opportunities are identified, these individuals must document, or register, the total collection of opportunities; this therefore creates an inventory of ideas and entrepreneurial individuals must act on attractive opportunities at the most appropriate times (McGrath & MacMillan 2000). The third characteristic of the entrepreneurial mindset is the pursuit of the best opportunities – entrepreneurial individuals must pursue the best opportunities and avoid becoming exhausted by chasing after every option (McGrath & MacMillan 2000). The most successful entrepreneurial individuals are disciplined, strategic, and concentrate their efforts on the right projects, thereby limiting the number of opportunities and projects that they pursue (McGrath & MacMillan 2000). The fourth characteristic of the entrepreneurial mindset is the execution of these opportunities – entrepreneurial individuals must focus on execution; specifically, on adaptive execution (McGrath & MacMillan 2000). This means that entrepreneurial individuals move ahead with their potential ideas instead of overanalysing them, and also adapt or change direction as the opportunity and the way in which to exploit it evolves (McGrath & MacMillan 2000). Finally, the fifth characteristic of the entrepreneurial mindset is the engagement of relevant individuals – entrepreneurial individuals must seek to engage the energies of all the people who are present in their domain (McGrath & MacMillan 2000). This requires building and sustaining networks, making use of all available resources regardless of ownership, and ensuring that all people in the network achieve their goals (McGrath & MacMillan 2000).

The possession of the Entrepreneurial mindset therefore allows Entrepreneurial Engineers to engage in the entrepreneurial process. This mindset can be seen as a way of analysing a situation in order to demonstrate an awareness and understanding of the prospective market, potential competitors, and risks associated with the introduction of a new product or technology into the market (Shartrand et al. 2008). Furthermore, possession of the mindset provides engineers with the capability of creating ventures, operating in established companies/organisations, or becoming part of universities or non – profit organisations (Weaver & Rayess 2010). The Entrepreneurial mindset can be taught to students in an educational environment (Shartrand et al. 2008). It can be developed through entrepreneurship education; in particular through experiential learning and entrepreneurial practice, and by experiences with mentors (Zappe et al. 2013). From the description of the characteristics presented, it can be seen that the key element of the entrepreneurial mindset is opportunity. The possession of an entrepreneurial mindset enables individuals to continuously search for, identify, and exploit opportunities (Ohland et al. 2004a).

2.3.2: Entrepreneurial Competencies

In addition to the Entrepreneurial mindset, research has shown that Entrepreneurial Engineers require specific competencies that enable them to act in an entrepreneurial manner. An entrepreneurial competency is a combination of knowledge, skills, and resources that help to distinguish an entrepreneurial individual (Fiet 2000a). Possession of a particular competency means that an individual has a combination of knowledge, skills, attitudes, values, and behaviours that are required to successfully perform a particular activity or task (Brophy & Kiely 2002; Rankin 2004). Being proficient in specific competencies is directly related to higher levels of performance or productivity (Bryant & Poustie 2001; Hartle 1995; Hayton & Kelley 2006; Shook et al. 2003).

Entrepreneurial competencies differ from those required for the daily operation of a business, which include, for example, the abilities to sell, produce, supervise employees, arrange finance and price, and arrange supply chain and logistics issues (Barringer & Ireland

2011). These business-focused competencies do not meet the specific requirements that are applicable in an entrepreneurial context (Morris et al. 2013b). This demonstrates that a distinct set of competencies specifically suited to the occurrence of entrepreneurial activity exists (Morris et al. 2013b) and these competencies must be developed in combination with those required for business operation (Rasmussen et al. 2011).

The most recent research into the competencies required for entrepreneurial behaviour was conducted by Morris et al. (2013b), who, using input from a panel consisting of successful entrepreneurs and top entrepreneurship educators, determined that a total of thirteen competencies were necessary to enable the occurrence of entrepreneurial activity. As explained in section 2.2, the core of entrepreneurship is the creation, existence, discovery, assessment, and exploitation of opportunity (Shane & Venkataraman 2000; Venkataraman 1997). Therefore, entrepreneurial competencies must enable the discovery or creation of opportunities, the assessment of opportunities, and the exploitation of opportunities in the form of innovation, proaction and risk (Shane & Venkataraman 2000; Venkataraman 1997). The Morris et al. (2013b) entrepreneurial competencies support this interaction with opportunity by demonstrating a capacity for the recognition, assessment, and exploitation of opportunities to occur. The researchers grouped the thirteen competencies into two broad categories: Behavioural competencies and Attitudinal competencies; with nine of these competencies belonging to the former category, and the remaining four in the latter category. This is presented in Table 2.

Table 2: Entrepreneurial Competencies

Adapted from Morris et al. (2013b)

The competencies necessary for the occurrence of entrepreneurial activity		
Category of Competencies	**Total number of Competencies**	**Competencies belong to category**
Behavioural Competencies	9	• Opportunity Recognition • Opportunity Assessment • Risk Management/Mitigation • Conveying a Compelling Vision • Creative Problem Solving/Imaginativeness • Resource Leveraging • Guerrilla Skills • Value Creation • Building and Using Networks
Attitudinal Competencies	4	• Tenacity/Perseverance • Maintain Focus yet Adapt • Resilience • Self-Efficacy

The behavioural competencies reflect the ability to take advantage of opportunities; while the four attitudinal competencies support the execution of the behavioural competencies which allow opportunities to be recognised and taken advantage of (Morris et al. 2013b).

The first two behavioural competencies of *Opportunity Recognition* and *Opportunity Assessment* relate specifically to an individual and his or her ability to either recognise or create opportunities, and then decide whether or not the opportunity is worth pursuing. More specifically, *Opportunity Recognition* is ‘the capacity to perceive changed conditions or overlooked possibilities in the environment that represent potential sources of profit ore return to a venture’, while *Opportunity Assessment* is ‘the ability to evaluate the content structure of opportunities to accurately determine their relative attractiveness’ (Morris et al. 2013b, p. 358). Being entrepreneurial involves viewing problems as opportunities; and therefore, Entrepreneurial Engineers need to be capable of identifying and seizing opportunities, or creating opportunities by discovering ideas and transforming them into opportunities (Arion 2013; Beattie 2000; Byers et al. 2013; Goldberg 2006). In transforming ideas, there must be recognition and acceptance that not all ideas will succeed, some may be a surprise, and some may not be fully appreciated at the time of discovery (Beattie 2000).

Risk Management is an important behavioural entrepreneurial competency. This refers to 'the taking of actions that reduce the probability of a risk occurring or reduce the potential impact if the risk were to occur' (Morris et al. 2013b, p. 358). Traditionally, engineers were risk-averse; Entrepreneurial Engineers are however required to be risk-takers (Byers et al. 2013; D'Cruz & O'Neal 2004; Kriewall & Mekemson 2010; Lumsdaine & Binks 2003; Nichols & Armstrong 2003; Shartrand et al. 2008; Zappe et al. 2013). Entrepreneurial Engineers must take risks in their activities, for example, in experimentation (Bailetti 2012), the operation of engineering businesses (Nichols & Armstrong 2003), and the creation of new products and services from innovative technologies (Polczynski & Jaskolski 2005).

It is important for entrepreneurial individuals to convey a compelling vision. *Conveying a Compelling Vision*, relates to 'the ability to conceive an image of a future organisational state and to articulate the image in a manner that empowers followers to enact it' (Morris et al. 2013b, p. 358). Entrepreneurial Engineers must have the ability to visualise (Beattie 2000). They must also be able to effectively communicate their ideas (Arion 2013; Bilén et al. 2005; Byers et al. 2013; Creed et al. 2002; Frank 2007; Goldberg 2006; Kriewall & Mekemson 2010; Sheppard et al. 2004; Shuman et al. 2005; Somerville et al. 2005; Stone et al. 2005; Swearengen et al. 2002), which can be achieved in a number of different ways, including continuous writing and revisions and the delivery of effective presentations, both of which go hand in hand with effective written and oral delivery (Goldberg 2006).

Creative Problem Solving or *Imaginativeness* is a behavioural competency required for entrepreneurial activity to occur. *Creative Problem Solving* is 'the ability to relate previously unrelated objects or variables to produce novel and appropriate or useful outcomes' (Morris et al. 2013b, p. 358). Entrepreneurial Engineers must take charge and use their initiative; they must be forerunners and leaders where they aim to be the first to do something, especially in terms of finding solutions (Newport & Elms 1997; Sundar & Madhavan 2013). This requires Entrepreneurial Engineers to be decisive (Hofer & Sandberg 1987; Newport & Elms 1997), where they must first be able to define problems and then solve the problems or situations at task (Beattie 2000; Bilén et al. 2005; Frank 2007; Torres et al. 1997) by breaking down a problem into parts and studying the parts and the relationships that exist between the parts (Sheppard et al. 2004; Shuman et al. 2005; Somerville et al. 2005;

Swearengen et al. 2002), whilst also employing creative reasoning and logic (Newport & Elms 1997). This means that Entrepreneurial Engineers must be creative in terms of the ideas derived and the measures employed (Byers et al. 2013; Frank 2007; Oosterbeek et al. 2010; Sheppard et al. 2004; Shuman et al. 2005; Somerville et al. 2005; Swearengen et al. 2002).

Entrepreneurial individuals require the behavioural competency of *Value Creation*. *Value Creation* refers to the 'capabilities of developing new products, services, and/or business models that generate revenues exceeding their costs and produce sufficient user benefits to bring about a fair return' (Morris et al. 2013b, p. 358). Entrepreneurial Engineers must have the ability to be technologically innovative (Sheppard et al. 2004; Shuman et al. 2005; Somerville et al. 2005; Swearengen et al. 2002). By being technologically innovative in their approaches, Entrepreneurial Engineers will be able to create value for end-users in the society – they must have the ability to engineer products for commercialisation, and be capable of creating products for the desired needs of the market that can be designed and tested for market consumption (Kriewall & Mekemson 2010).

Guerrilla Skills is another behavioural competency required by entrepreneurial individuals. *Guerrilla Skills* involve 'the capacity to take advantage of one's surroundings, employ unconventional, low-cost tactics not recognised by others, and do more with less' (Morris et al. 2013b, p. 358). Entrepreneurial Engineers are required to exhibit great foresight where they are able to self-project into the future and make predictions of future behaviour and demands based on known evidence and observations (Goldberg 2006; Hambrick & Crozier 1986; Mitton 1989; Newport & Elms 1997; Sundar & Madhavan 2013). These predictions are essential particularly in cases where the available pool of resources is restricted, and as a result, Entrepreneurial Engineers must be able to meet the needs of society even when faced with limited resources (Frank 2007).

Building and Using Networks and *Resource Leveraging* are the final two behavioural competencies required by entrepreneurial individuals. First, *Building and Using Networks* refers to the 'social interaction skills that enable an individual to establish, develop, and maintain sets of relationships with others who assist them in advancing their work or career (Morris et al. 2013b, p. 358). In the Entrepreneurial Engineering context, Entrepreneurial

Engineers, as discussed in section 2.2, are required to work on multidisciplinary teams (Ohland et al. 2004a; Yurtseven 2002). This is because Entrepreneurial Engineers understand the importance of creating and maintaining networks since they recognise the need for others to help turn ideas into reality (Aldrich et al. 1987). *Resource Leveraging*, on the other hand, refers to 'skills at accessing resources one does not necessarily own or control to accomplish personal ends' (Morris et al. 2013b, p. 358). The members of networks each possess their own resources, and through these networks, individuals can gain access to resources that are controlled by others within the network; a collaborative effort that enables for goals to be met (McGrath & MacMillan 2000). Entrepreneurial Engineers must therefore share resources in order to transform ideas into reality (Aldrich et al. 1987).

Entrepreneurial individuals require a further four attitudinal competencies to support the occurrence of the behavioural competencies. The first is *Tenacity* or *Perseverance*, which is 'the ability to sustain goal-directed action and energy when confronting difficulties and obstacles that impede goal achievement (Morris et al. 2013b, p. 358). Entrepreneurial Engineers must be able to set goals as well as persevere to achieve these goals (Beattie 2000; Goldberg 2006; Sundar & Madhavan 2013). They must not only believe in ideas, but also work toward the achievement of these ideas by having a strong work ethic and being organised (Goldberg 2006).

It is also important that entrepreneurial individuals are able to maintain focus while adapting. The attitudinal competency *Maintain Focus yet Adapt* is 'the ability to balance an emphasis on goal achievement and the strategic direction of the organisation while addressing the need to identify and pursue actions to improve the fit between an organisation and developments in the external environment' (Morris et al. 2013b, p. 358). It is important that Entrepreneurial Engineers be flexible and able to cope with change (Täks et al. 2014), as well as ready and willing to participate in change (Swearengen et al. 2002). Entrepreneurial Engineers must therefore accept change as a natural element of their environment (Swearengen et al. 2002).

Finally, Entrepreneurial Engineers must demonstrate *Resilience* (Byers et al. 2013), and *Self-Efficacy* (Beattie 2000). *Resilience* is 'the ability to cope with stresses and disturbances such that one remains well, recovers, or even thrives in the face of adversity' (Morris et al. 2013b,

p. 358). Entrepreneurial Engineers must quickly recover in the face of problems, and move forward despite the occurrence of setbacks (Byers et al. 2013), which means they must have calm attitudes to support the handling of pressure and recovery in times of crises (Newport & Elms 1997). Entrepreneurial Engineers also require *Self-Efficacy*, which is 'the ability to maintain a sense of self-confidence regarding one's ability to accomplish a particular task or attain a level of performance' (Morris et al. 2013b, p. 358). When Entrepreneurial Engineers have Self-Efficacy, they have confidence in their abilities to perform given tasks and know when their goals are attainable, in addition to a strong sense of self-belief which shows what they want, what they are capable of achieving, and how to go about accomplishing it (Beattie 2000; Newport & Elms 1997; Sundar & Madhavan 2013; Zappe et al. 2013).

2.3.3: Entrepreneurial Knowledge and Skills

Entrepreneurial Engineers, like other entrepreneurial individuals, must be able to fully engage in the opportunity identification, analysis, and exploitation processes. For this to occur, specific knowledge is required. Entrepreneurial Engineers are first and foremost engineers, which means that they must possess the same technical knowledge and knowledge of engineering fundamentals possessed by traditional engineers, and transform this knowledge into practical use (Kriewall & Mekemson 2010; Lumsdaine & Binks 2003). This includes engineering-focused analysis, knowledge of user-requirements and performance specifications, and knowledge of the design process and associated issues (Kriewall & Mekemson 2010).

Second, it is important for Entrepreneurial Engineers to possess knowledge of business fundamentals and have a basic understanding of business-related concepts, including marketing, finance, and economics (Lumsdaine & Binks 2003; Morris et al. 2013b; Rasmussen et al. 2011). Entrepreneurial Engineers need to know about business, or more specifically, what business entails, and how it works (Bilén et al. 2005; Lumsdaine & Binks 2003; Newport & Elms 1997; Stone et al. 2005; Sundar & Madhavan 2013). This includes knowledge of finance (Bilén et al. 2005; Stone et al. 2005), a sense of money (Sundar & Madhavan 2013) and an understanding of leadership and organisation (Goldberg 2006). In addition, Entrepreneurial Engineers must have knowledge of the organisational culture, leadership and management roles and business practices, good communication skills, interpersonal and team-working skills, and the roles that engineers play within organisations (Kriewall & Mekemson 2010). Business knowledge and fundamentals aid in the identification of business-related opportunities, which in turn can be used for the operation of new ventures (Barringer & Ireland 2011) as well as the undertaking of new activities in existing organisations (Maier & Pop Zenovia 2011).

Third, Entrepreneurial Engineers must be in tune with their customers. They must first have an understanding of the business environment within which they operate, and then have an understanding of the needs of potential customers, including knowledge and awareness of potential markets and competitors both at local and global levels (Binks et al. 2006; Kao 1993; Oosterbeek et al. 2010; Stone et al. 2005). By engaging with customers, engineers will be able to think outside the box to act on opportunities that address unmet customer needs, define identified problems, create and deliver customer value, and/or potentially create new markets (Kriewall & Mekemson 2010).

Finally, Entrepreneurial Engineers must be socially oriented (Kao 1993; Oosterbeek et al. 2010), and therefore must be aware of the issues that have arisen which impact society (Kao 1993). Having this knowledge allows entrepreneurs to appropriately find solutions to the needs of individuals and communities at a local, national, and global level (Bacq & Janssen 2011; Bornstein & Davis 2010; Thompson 2002). Unlike the engineers of the past, engineers today need to consider the society within which they are based and more specifically, and think about human and other non-technical factors (Creed et al. 2002; Stone et al. 2005). This means that any decisions made must explicitly demonstrate the fact that these factors were taken into consideration (Creed et al. 2002; Stone et al. 2005).

For Entrepreneurial Engineers to demonstrate their knowledge, they need both technical and engineering and business and management skills. First, once Entrepreneurial Engineers possess engineering knowledge, they must be able to apply and use this knowledge as well as be able to think in a technical manner (Sundar & Madhavan 2013) particularly when it comes to addressing engineering problems that exist within the environment and other roles that engineers may ultimately play. This means that Entrepreneurial Engineers must possess technical and engineering skills (Lumsdaine & Binks 2003). Entrepreneurial Engineers also require business skills. They need to exhibit their business knowledge and show that they can survive in the start-up and small and medium sized enterprise environments that require them. Furthermore, they need to be capable of negotiating (Frank 2007), as well as making plans, understanding and navigating the product life cycle and addressing the legal and intellectual property issues that could potentially arise (Arion 2013). In addition to business skills, Entrepreneurial Engineers also need to have management abilities. They must show that they can manage projects, finances, and supply chains (Arion 2013), and they must show their people skills by not only being able to collaborate and work with teams but also showing that they can effectively manage and lead both people and teams (Arion 2013; Bilén et al. 2005; Byers et al. 2013; Chandler & Jansen 1992; Creed et al. 2002; Frank 2007; Newport & Elms 1997; Sheppard et al. 2004; Shuman et al. 2005; Somerville et al. 2005; Stone et al. 2005; Swearengen et al. 2002).

Entrepreneurial Engineers are therefore clearly distinct. Not only do they possess an entrepreneurial mindset, but they also must possess a technologically-oriented background in addition to multidisciplinary knowledge and skills that are required to act in an entrepreneurial capacity in world economies. These new expectations must therefore be taken into consideration when designing educational programmes for the creation of these engineers.

2.4: The Roles of the Entrepreneurial Engineer

With the roles of engineers expanding to non-traditional and entrepreneurial areas, being entrepreneurial in an engineering context means that engineers must also possess the characteristics that helps them to function both within and outside the original boundaries of engineering. The employment opportunities of engineers today have expanded beyond large companies to include employment in established small- and medium-sized companies or employment in their own business ventures (Kriewall & Mekemson 2010). As a result, entrepreneurial engineers must occupy more roles than they did in previous decades; both technical and non-technical roles. More specifically, Entrepreneurial Engineers occupy four distinct roles: Engineer, Intrapreneur, Entrepreneur, and Social Entrepreneur.

In a technical context, Entrepreneurial Engineers are first and foremost engineers, which requires them to occupy traditional engineering roles (Kriewall & Mekemson 2010).

Traditional engineers use mathematics and science to address the challenges that arise in society (Kriewall & Mekemson 2010). They are problem solvers – they analyse problems and design products and solutions using their technical knowledge and tried and tested methods, they know what to do to solve problems and how to do it once they understand the problem they are faced with, they avoid interacting with end-users, and they prefer the more stable and secure employment opportunities offered and large and medium-sized organisations (Kriewall & Mekemson 2010; Polczynski & Jaskolski 2005).

In a non-technical context, Entrepreneurial Engineers must act, as the name suggests, in an entrepreneurial manner. As explained in section 2.2, entrepreneurship is about searching for, identifying, and developing opportunities, and then exploiting the opportunities either in the form of new firm creation or within existing organisations (Shane & Venkataraman 2000). The first non-technical role that Entrepreneurial Engineers must occupy is the role of Intrapreneur within organisation in which they are employed (Kriewall & Mekemson 2010). Intrapreneurs are the ones who pursue opportunities to do something new (Vesper 1990), where they implement new ideas and have the freedom to create and market their own ideas (Haskins & Williams 1987) while operating in an existing organisation (Bosma et al. 2010). When engineers take on the Intrapreneur role, they choose a more engaged role in product redesign or the new product creation and development process in order to create improvements that enable existing products to stay ahead of competitors' products (Kriewall & Mekemson 2010). They take the core competencies of the organisation that they are employed in and use these to help the organisation to become competitive by gaining entry into new markets, or a greater share of existing markets (Kriewall & Mekemson 2010). Unlike traditional engineers, engineers in the Intrapreneur role want to interact with end-users in order to identify the unspoken needs of customers and determine how to meet these needs; therefore, they focus on technological design and product design and creation that provide benefits to markets and customers (Kriewall & Mekemson 2010). In addition, Entrepreneurial Engineers acting as Intrapreneurs are more comfortable with risk and making decisions with limited information available, work hard to get the products to market in as short a time as possible while taking company cash into consideration, occupy managerial and leadership roles within their organisations, and are either members or leaders of new business or product development teams at medium-sized companies, or employed in start-up, high-risk, work environments (Kriewall & Mekemson 2010).

Secondly, Entrepreneurial Engineers must be Entrepreneurs; in occupying an entrepreneurial role, Entrepreneurial Engineers must be market innovators and market leaders (Kriewall & Mekemson 2010). They tend to be more motivated to break the mould in order to be competitive and create brand new markets (Kriewall & Mekemson 2010). Being an entrepreneur means that engineers must be motivated to use new technologies to create new markets or compete in existing ones, be more risk-taking as opposed to being risk-averse, participate in business development, must have and be able to clearly communicate the vision of the organisation within which they operate, and create and develop products that meet or exceed end-user expectations and improve the lives of all those in society, all while being ethical (Kriewall & Mekemson 2010). When engineers become entrepreneurs, they have a personal financial stake in new enterprises or the organisations within which they work and the activities they undertake; they invest in firms where they work or assume the risk and management of engineering business enterprises (Kriewall & Mekemson 2010).

The final non-technical role of Entrepreneurial Engineers is the role of Social Entrepreneur (Hoy 2014). Social Entrepreneurs are the ones that create change within a society by addressing social problems within society using innovative means and the resources that are available to derive something that bestows benefits upon society (Bornstein 2004; Dees 2001; Defourny & Nyssens 2008; Shaw & Carter 2007; Thompson 2002). As a result, for Entrepreneurial Engineers to be Social Engineers they must contribute to the occurrence of socially responsible engineering, which in turn, can also contribute to sustainable growth (Yackovlev & Scavarda 2010). Acting in this role means that engineers must be able to identify how their ideas fit into the larger context of society given that their work can greatly impact society (Kriewall & Mekemson 2010). Entrepreneurial Engineers must therefore ensure that their selected actions influence society in a positive way, while preserving the freedom and standard of living present and working to the benefit of others (Kriewall & Mekemson 2010). It is therefore important that engineers become more socially oriented, where they participate in social entrepreneurship and pursue innovative solutions to social problems (Hoy 2014). In order to do so, engineers need to use their technical background to develop technologies that can provide solutions to society's problems.

The demand for, and importance of, Entrepreneurial Engineers has made it necessary to comprehend how engineering students acquire the entrepreneurial characteristics in order to graduate students who are prepared to function in the new engineering arena. This requires a deeper understanding of how tertiary-level academic institutions are using entrepreneurship education to develop entrepreneurial attributes in their engineering students. This will be further explored in Chapter 3.

Chapter 3: Literature Review Part II

3.1: Introduction

Chapter 3 presents the educational approaches that are used to produce Entrepreneurial Engineers. The chapter commences with a discussion of the roles played by tertiary-level academic institutions in the creation of entrepreneurial graduates and the overall entrepreneurship education process. It then continues with defining entrepreneurship education and highlighting the importance of entrepreneurship education, and discusses the changes that have occurred in, and structure of, entrepreneurship education. Next, the chapter continues with a discussion of how engineering education has evolved, how academic institutions have responded to the need for Entrepreneurial Engineers, and a description of the entrepreneurship initiatives that have been created for engineering students. The chapter then discusses the Standish-Kuon and Rice (2002) typology, which presents previous research on how tertiary-level academic institutions introduce entrepreneurship to their engineering, as well as science, students, and concludes with a discussion of the gap in the literature of the overall PhD research study.

3.2: The Role of Tertiary-Level Academic Institutions in the creation of entrepreneurial individuals

Tertiary-level academic institutions play an important role in the Human Capital domain of the entrepreneurship ecosystem (Isenberg 2011; World Economic Forum 2013). The entrepreneurship ecosystem is an environment with interconnected relationships influenced by a variety of factors, which link people by vision, commitment, passion, and innovation surrounding the achievement of a common goal (Pistrui et al. 2008). Tertiary-level institutions are the source of the entrepreneurial individuals that are needed at a global societal level, arming individuals with the entrepreneurial vision, knowledge, and skills which allow for the recognition and exploitation of these opportunities and the development of solutions (Elia et al. 2011; Frazão et al. 2007; Henry et al. 2003; Herrmann et al. 2008; Kirby 2007; Lucas & Cooper 2004; Rasmussen & Sørheim 2006; Taatila 2010). They also promote and provide entrepreneurship education and training, which in turn creates labour in the form of entrepreneurs who operate in the ecosystem (Henry et al. 2003; Isenberg 2011), thereby promoting change (Frazão et al. 2007; Kirby 2007).

To create entrepreneurial individuals, it is important for tertiary-level academic institutions to create an environment and organisational culture that facilitates the teaching of entrepreneurship and the ability to learn think, learn, and behave in an entrepreneurial manner (Bygrave & Zacharakis 2009; Frazão et al. 2007). These institutions must also provide the relevant human resources who are knowledgeable in different entrepreneurial areas (Frazão et al. 2007), as well as allow for the shaping of entrepreneurial cultures and aspirations of students which potentially lead to the development of regional and societal economies (Autio et al. 1997; Binks et al. 2006; Co & Mitchell 2006; Landström 2007; Mahlberg 1996). Therefore, tertiary-level academic institutions should become an entrepreneurial environment where entrepreneurship and entrepreneurial activity amongst the students are supported (Gnyawali & Fogel 1994; Roffe 1996), where ideas for new companies can be formed and graduates can be created who can be employed in these new companies (World Economic Forum 2013), and where business creation, continuous organisational renewal and improvement, sustained competitiveness, and overall economic development can be encouraged (Binks et al. 2006). Providing entrepreneurship education is vital to creation of such an environment.

Entrepreneurship education has become increasingly important (Abdulwahed et al. 2013a; De Faoite et al. 2003; Elmuti et al. 2012; Henry et al. 2003). For example, entrepreneurship education must create individuals who are able to recognise and exploit opportunity, cope with uncertainty, comprehend in the face of chaos, and anticipate, initiate and cope with change (Kirby 2007). It must also create individuals who can create and develop small innovative enterprises, recognise, exploit, and implement entrepreneurship opportunities, state the goals of any new activities, create business plans, know sources for finances and potentially acquire resources, and ultimately be able to manage the resultant business (Frazão et al. 2007). The promotion of entrepreneurship education can also stimulate the occurrence of entrepreneurial activities, for example, the creation of entrepreneurial ventures (Blenker et al. 2011; Falkäng & Alberti 2000; Heinonen & Poikkijoki 2006). The teaching environments of tertiary-level academic institutions, as a result, have the greatest influences impacting students' perceptions of entrepreneurship and the overall intention to an entrepreneurial career (Autio et al. 1997; Keat et al. 2011; Mueller 2011; Rasli et al. 2013). Research has shown that entrepreneurship can be learned and practiced in classroom settings (Fiet 2000a), which means that entrepreneurship competencies and abilities can be developed and improved with education and training (Abdulwahed et al. 2013a; Bryant & Poustie 2001; Heinonen & Poikkijoki 2006).

To meet the growing need for engineering graduates who possess entrepreneurial knowledge and skills, different university-based entrepreneurship educational initiatives have been and are being created (Duval-Couetil 2013; Gorman et al. 1997; Hynes & Richardson 2007; Katz 2003; Klofsten 2000; Kuratko 2005; Rideout & Gray 2013; Solomon & Fernald 1991; Vesper & Gartner 1997). University-based entrepreneurship initiatives are courses and co-curricular/extra-curricular activities that teach entrepreneurial management, strategy, innovation, and venture development in a university setting (Rideout & Gray 2013). Tertiary-level academic institutions have created, and are still creating, educational courses, programmes, seminars, and other educational initiatives that enable students from a variety of academic disciplines to acquire entrepreneurial knowledge and competencies (Duval-Couetil 2013; Katz 2003; Klofsten 2000; Kuratko 2005; Solomon & Fernald 1991; Vesper & Gartner 1997). The aim of these initiatives is to encourage the occurrence of enterprising activities which in turn encourage small business and economic growth (Gordon et al. 2010; Hynes & Richardson 2007). Furthermore, these academic institutions prepare students for the real world by increasing the availability of entrepreneurial activities and experiential educational programmes such as business plan and product development competitions, technology commercialisation activities, and internships with start-up ventures (Duval-Couetil 2013).

The purpose of these entrepreneurship initiatives, in addition to the encouragement of entrepreneurial activities, is to facilitate entrepreneurial learning. Entrepreneurial learning is about the transformation of experience and knowledge into functional learning outcomes, and is comprised of knowledge, behaviour, and effective or emotional learning (Cope 2005). It is a process which involves the acquisition of entrepreneurial skills (Täks et al. 2014); as well as recognising, creating, and acting on opportunities in innovative and opportunistic ways (Rae 2003, 2006). Entrepreneurial learning can be social and organisational, or individual, which take into account that personal differences in ability produce different learning outcomes (Corbett 2005). It is influenced by the context within which learning occurs, and includes the content of what is learned as well as the processes through which learning takes place (Politis 2005). The process of entrepreneurial learning is closely linked to the processes of opportunity recognition (Dutta & Crossan 2005), creativity, innovation, and opportunity exploitation (Lumpkin & Lichtenstein 2005).

In summary, tertiary-level academic institutions play an important role in the creation of entrepreneurial graduates. These institutions prepare the labour needed in world economies by offering a variety of entrepreneurship initiatives that are designed to teach students the knowledge and skills needed to act in an entrepreneurial manner. They also create environments which can foster the entrepreneurial learning of students and potentially encourage students' entrepreneurial intention. However, to gain a deeper understanding of entrepreneurship education and its effect, it is necessary to acquire further insight into the inner workings of entrepreneurship education. This will be the focus of the following section.

3.3: Definition and the Importance of Entrepreneurship Education

It is important for world economies to invest in the development of human capital through entrepreneurship education given that human capital is able to create economic growth through knowledge (Acs et al. 2004; Acs et al. 2009). Entrepreneurship education is the result of the belief that entrepreneurship can, and should, be taught (Fiet 2000a; Gibb 2002; Henry et al. 2005a), and not based on the belief that specific genes are required for entrepreneurial behaviour to occur (Baumol 1983; Katz 1981; Kuratko 2005). It is seen as an effective way of preparing graduates to either become entrepreneurs owning their own enterprises or employees in small businesses (Hynes & Richardson 2007). It is used to train students and arm them with the knowledge and skills that can be used to recognise and act on opportunities (Jones & English 2004). Within the entrepreneurship education process, the focus is on the individuals' development of the knowledge, skills, and attitudes that are necessary for the identification and recognition of a business opportunity, coping with risk while organising resources, and the creation of a business venture either in the form of a new venture or further development of an existing company (Béchard & Toulouse 1998; Kourilsky 1995). For entrepreneurship education to be effective, the initiatives must equip students with the knowledge, skills, and competencies that are required to be flexible, innovative, and enterprising in an evolving work environment (Hynes & Richardson 2007).

Entrepreneurship education is increasing in importance worldwide due to global and organisational changes (Arasti et al. 2012; Gibb 2002; Henry et al. 2005a). One of the major benefits of promoting entrepreneurship is the ability to develop an understanding and clarification of the entrepreneurship field (Abdulwahed et al. 2013a). Entrepreneurship education is responsible for the dissemination of entrepreneurship knowledge (Katz et al. 2014a). In addition, the teaching of entrepreneurship helps to increase students' knowledge of entrepreneurship and stimulate entrepreneurship research, and then subsequently improve policy-making and the curriculum for entrepreneurship (Brand et al. 2006).

The promotion of entrepreneurship education is also used for the personal development of learners through the enhanced awareness of learners' own abilities and the creation of the learners' entrepreneurial mindset (Täks et al. 2014; Wilson 2008). Furthermore, it facilitates the development of the entrepreneurial skills, attitudes, activity, aspirations, competencies, and culture of the students (Papayannakis et al. 2008; Regele & Neck 2012). As a result, entrepreneurship education is important in stimulating the entrepreneurial potential of individuals (Sundar & Madhavan 2013), and students who participate in entrepreneurship initiatives tend to be more innovative, possess a higher risk-taking propensity, and have a higher desire to be entrepreneurial (Gürol & Atsan 2006; Koh 1996).

Entrepreneurship education is important in developing an entrepreneurial culture within a country (Arasti et al. 2012; Azizi 2009; Nel et al. 2008). It can be used to facilitate and promote the occurrence of entrepreneurial activities which contribute to entrepreneurship development within society and address issues and challenges faced (Akola & Heinonen 2006; Matlay 2005; O'Connor 2013; Papayannakis et al. 2008). It can also be promoted in order to enhance economic growth and development (Mueller 2011). To encourage economic growth and development, entrepreneurship education plays an important role in moving students' intentions towards becoming entrepreneurial and creating favourable attitudes towards entrepreneurial activities (Abdulwahed et al. 2013a; Arasti et al. 2012;

Autio et al. 1997; Azizi 2009; Gerba 2012; Gorman et al. 1997; Johannisson 1991; Kolvereid & Moen 1997; Kourilsky & Walstad 1998; Liñán et al. 2011; Mueller 2011; Noel 2001; Peterman & Kennedy 2003; Tkachev & Kolvereid 1999; Tung 2011; Von Graevenitz et al. 2010). Entrepreneurship education stimulates interest in entrepreneurship (Fayolle & Gailly 2008). It helps students to develop an entrepreneurial spirit, as well as an interest in entrepreneurship by promoting a positive image of entrepreneurs and the roles that they play in society (Fayolle & Gailly 2008). Furthermore, entrepreneurship education can develop students' self-efficacy (Abdulwahed et al. 2013a; Hood & Young 1993; Mueller 2011; Tung 2011) and directly impact entrepreneurial behaviour (Donckels 1991; Gasse 1985; Kolvereid & Moen 1997; Tkachev & Kolvereid 1999).

Stemming from economic development and entrepreneurial intention, entrepreneurship education is primarily important in addressing the employment challenges faced by today's global economy. Entrepreneurship education can help students to consider pursuing an entrepreneurial career (Abdulwahed et al. 2013a; Charney & Libecap 2003; Lange et al. 2011), and result in the development and creation of new employment opportunities which reduce levels of employment and increase the levels of income within a nation's economy (McMullan & Long 1987; OECD 2001; Sweeney 1998). The use of entrepreneurship education can help individuals to develop entrepreneurial knowledge and skills, which can be used to enhance the competitive advantage of a nation's economy (Kennedy 1993) and help these individuals to consider entrepreneurship as a good career option (Lucas & Cooper 2004). It can also be used as a way of providing students with entrepreneurial activities and opportunities for the potential emergence of entrepreneurial small- and medium-sized enterprises (Abdulwahed et al. 2013a). A major goal of entrepreneurship education, when it comes to addressing employment challenges, is the promotion of new venture creation – entrepreneurship education provides students with the motivation, knowledge, and skills that are essential for the creation of new enterprises (Abdulwahed et al. 2013a; Arasti et al. 2012; Cho 1998; Lucas & Cooper 2004; Tung 2011). The knowledge and skills required for the venture creation process includes, for example, the abilities to identify business opportunities, plan and manage projects and associated finances, manage people and team, communicate effectively, and handle legal and intellectual property issues (Arion 2013; Schaper & Casimir 2007). The creation of new business ventures is valuable and encouraged due to the fact that educated entrepreneurs generally create innovative ventures that experience higher levels of growth and survival and engage in more international activities (Ching & Ellis 2004) and generally positively influence society (Brand et al. 2006). By stimulating interest in venture creation, students have a greater possibility of engaging in entrepreneurial activities (Minniti et al. 2006).

Students also receive opportunities to gain entrepreneurial experience in a real business context (Autio et al. 1997; Blenker et al. 2011; Crispin et al. 2013; Falkäng & Alberti 2000; Gorman et al. 1997; Johannisson 1991; Kourilsky & Walstad 1998). Practical experiences place students in real-situations which echo those actually present in the business environment; including, for example, the creation and development of business plans, and working in start-up ventures or classroom simulations (Von Graevenitz et al. 2010), and the launch of new business ventures (Abdulwahed et al. 2013a; Blenker et al. 2011; Falkäng & Alberti 2000). Undertaking these practical experiences provides students to assess their own entrepreneurial abilities and determine whether or not they want to pursue an entrepreneurial career (Von Graevenitz et al. 2010). The nurturing of potential entrepreneurs through the provision of entrepreneurial activities through entrepreneurship education can generate valuable long-term benefits, for example, a decrease in the unemployment levels, an increase in new venture creation, and a reduction in the failure levels of existing businesses (Arthur et al. 2012; Hansemark 1998; Hatten & Ruhland 1995).

3.4: The Changes in Entrepreneurship Education

Tertiary-level academic institutions are the primary providers of entrepreneurship educational initiatives (Fayolle 2013), and the increase in demand for entrepreneurial attribute development has made it necessary for entrepreneurship education teaching approaches to simultaneously grow. Traditionally, entrepreneurship-based programmes and courses were offered by and situated in the business school (Byers et al. 2013; Kriewall & Mekemson 2010; Luryi et al. 2007). However, the way in which entrepreneurship education is offered has since evolved.

There has been increasing interest in entrepreneurship education, and as a result, there has been a great increase in the presence of entrepreneurship education initiatives in tertiary-level academic institutions, as well as a growth in the number of these institutions that offer entrepreneurship initiatives, worldwide (Arthur et al. 2012; Blenker et al. 2011; Falkäng & Alberti 2000; Gibb 1993; Katz 2003; Kuratko 2005; Kuratko & Hodgetts 2014; Neck & Greene 2011; Solomon et al. 2002). In these institutions, there has been a greater presence of support and facilities for entrepreneurship education. For example, more than 600 universities worldwide have created entrepreneurship centres and institutions, and an increasing number of tertiary-level academic institutions are creating entrepreneurship schools and academic departments (Morris et al. 2013a). Different reasons have been highlighted to justify this increase in entrepreneurship educational initiatives: to arm students with the knowledge and competencies necessary to enable the creation of economic value and jobs (Duval-Couetil 2013), the recognition that entrepreneurship plays a significant role in the creation of jobs and the economic growth in the society and helps to increase the levels of entrepreneurship that occur (Carree & Thurik 2003; Hynes 1996; Kuratko 2003, 2005), the connection that exists between entrepreneurship and innovation (Ching & Ellis 2004; Jack & Anderson 1999), and the increased need for entrepreneurial employees and subsequently intrapreneurship in existing organisations (Hayton 2004; Hornsby et al. 1999; Hornsby et al. 1993; Kuratko et al. 1990).

There is great diversity in entrepreneurship programmes, ranging from the schools within which they are housed, the methods and approaches used to teach the initiatives, and the subjects and content taught across different initiatives (Crispin et al. 2013). In the available literature, it has been noted that entrepreneurship education should not be confined to the business schools, but instead be offered in any school or major where the students will require entrepreneurial characteristics for their future careers (Katz et al. 2014a). We are now witnessing the move of entrepreneurship educational initiatives – including programmes, courses, and other entrepreneurial activities – away from being situated in one single school, centre, or department, typically the business school, towards being present in numerous schools, colleges, or departments of the tertiary-level academic institution, for example the Schools of Engineering, Agriculture, Arts and Sciences, Education, and Fine Arts (Cone 2004; Katz et al. 2014b; Klein & Bullock 2006; Kriewall & Mekemson 2010; Thorp & Goldstein 2013; West III et al. 2009). There has also been an increase in the range and type of entrepreneurship programmes that are being offered

(Hynes & Richardson 2007). For example, there are initiatives that are more focused, with entrepreneurship courses being taught in one school for the students specifically from that school and without the involvement of the faculty or students from any other school (Streeter et al. 2002). Another example is the presence of entrepreneurship initiatives that are offered campus-wide with related classes taught in a number of different locations (Katz et al. 2014b). In addition, there is a presence of new, interdisciplinary programmes created by combined faculty teams specifically for non-business students (Kuratko 2005).

There have also been changes in the offerings in the entrepreneurship educational initiatives and the students targeted. Entrepreneurship education is no longer only for business students – all graduates, regardless of discipline, must possess the knowledge and skills that are required for the changed work environment, which therefore make it necessary for entrepreneurship education to be present both within and outside the business discipline (Hynes & Richardson 2007; Kriewall & Mekemson 2010). Non-business students are valuable target groups for entrepreneurship education, and it is beneficial for non-business students to be educated about entrepreneurship (Brand et al. 2006). There has been an increase in entrepreneurship courses designed specifically for non-business students, for example, arts, science, and engineering students (Brand et al. 2006; Kriewall & Mekemson 2010; Kuratko 2005). This has seen the presence of courses in areas such as technological entrepreneurship, social entrepreneurship, arts entrepreneurship, and family business management (Klein & Bullock 2006). There has also been an increase in experiential activities geared at providing students with hands-on entrepreneurship experience (Blenker et al. 2011).

There are different reasons to support the promotion of entrepreneurship education for non-business students. For example, non-business students have a variety of characteristics that can enhance entrepreneurship potential, including knowledge in their respective domains which enable potential opportunities to be recognised (Shane 2000). The type of opportunities that will be identified by non-business students will be dependent on the personal and everyday-life of students in addition to specific knowledge from their respective fields of education which could be used to generate innovative ideas for new products, processes, services, or businesses (Brand et al. 2006). In addition, there is the knowledge that this awareness can be influenced by entrepreneurship education (Brand et al. 2006), and that the intention to start a venture may be stronger due to the fact that the students have not previously considered an entrepreneurial career (Krueger et al. 2000). An extension of this is the fact that non-business students lack business and managerial-related knowledge in addition to knowledge of the entrepreneurial process, which could result in students and their minimised awareness of their own entrepreneurial potential (Brand et al. 2006).

In the engineering discipline, the sentiments behind the integration of entrepreneurship and engineering education are echoed in the discussion of Science, Technology, Engineering, and Mathematics (STEM) education. A scientific-based education provides knowledge and skills that are beneficial to a variety of careers (West 2012). Businesses and other organisations in a variety of countries – for example, the United States, the United Kingdom, Canada, Australia, New Zealand, Brazil, Singapore, Japan, China, and members of the European Union – need individuals in scientific and technical areas in order to enable the competitive advantage of the countries (Charette 2013; Marginson et al. 2013). Science and Technology are seen as the answer to the complex issues faced by the global society (Marginson et al. 2013), with technological advances driving both societal and individual progress (Tremblay et al. 2012). STEM education has therefore become important, with a global need to improve STEM education due to society's complex issues (Kelley & Knowles 2016). STEM education can encourage the occurrence of science-and technology-based innovation, which is important in driving economic growth, stimulating job growth, addressing global challenges, driving country competitiveness, and enhancing quality of life (Atkinson & Mayo 2010). As a result, there is significant interest in building STEM skills through education due to the relationship between STEM skills and research and development and innovation (Marginson et al. 2013). In fact, the quality and quantity of STEM competencies are perceived as having an effect on the overall economic performance of a country (Marginson et al. 2013).

STEM education is very important to various countries (Marginson et al. 2013). In Australia, for example, there is greater demand for more STEM education in order to stimulate economic competitiveness and growth (Gough 2015), and produce the skills needed for the economy (Norton & Cakitaki 2013). With the end of Australia's mining boom, jobs for purely scientific graduates have declined and very few positions in their specific field typically arise (Marginson et al. 2013). STEM graduates must therefore be prepared to occupy job roles that are not specifically linked to their scientific qualifications (Marginson et al. 2013). This demonstrates that in Australia, STEM education is important to the economy because it guarantees that students are prepared for a variety of different careers by ensuring that they are taught the relevant skills (West 2012). Of all science professionals, engineers have the best employment outcomes and are more likely to use and apply their university learning in the workplace (Marginson et al. 2013). Furthermore, the commercialisation of research, resulting in new products and services, is a potential employment source for engineering and other STEM graduates (Marginson et al. 2013). Therefore, the skills acquired from STEM are needed in various economic sectors and, as a result, STEM education prepares students with the creative and analytical skills used in a broad range of occupations (Marginson et al. 2013; West 2012). Similarities can therefore be seen between the promotion of STEM education and the integration of entrepreneurship education into the engineering curriculum.

In summary, entrepreneurship education has evolved from being solely present in the business school. There has been a growth in the presence of entrepreneurship education and it is now increasingly being offered by a greater number of tertiary-level academic institutions worldwide. Entrepreneurship programmes today have also diversified; they are present in a number of different schools, include different content, and incorporate different teaching approaches. The target students have also changed, with programmes being created for students from a variety of different academic disciplines. Non-business students need to learn about entrepreneurship due to the incorporation of entrepreneurship in a variety of different fields. This change in entrepreneurship education requires a deeper understanding of how entrepreneurship education is structured. This will be addressed in section 3.5.

3.5: The Structure of Entrepreneurship Education

Section 3.5 is focused on describing the structure of entrepreneurship initiatives and discusses the objectives, outcomes, content, initiative offerings, teaching approaches, and cultural considerations.

3.5.1: The Objectives of Entrepreneurship Education Initiatives

The overall aim of entrepreneurship education is the development of entrepreneurial competencies which develop students' mindsets and represent combinations of specific behaviour, skills, knowledge and attitudes that students need to be entrepreneurial in the future (Chang & Rieple 2013; Fiet 2000a). Entrepreneurship educational initiatives are promoted around the world and involve specific objectives focused on the creation of entrepreneurial individuals who have a strong intent to become entrepreneurs, as well as broader objectives focused on the preparation of individuals to live entrepreneurial lives in today's world (Hytti & O'Gorman 2004). Objectives for entrepreneurship education vary according to factors such as the duration of the initiatives, the target audiences, the content taught in the initiatives, and the available resources (Azim & Al-Kahtani 2014). The objectives for entrepreneurship education initiatives are grouped into four distinct categories:

- To educate "about" entrepreneurship
- To educate "for" entrepreneurship
- To educate "through" entrepreneurship; and
- To educate "in" entrepreneurship

The first two categories are the two most common categories identified in the available literature. The first category, educating "about" entrepreneurship is focused on creating and developing an awareness of entrepreneurship (Falkäng & Alberti 2000; Fayolle 2007; Hytti 2002; Hytti & O'Gorman 2004; Jack & Anderson 1999; Jamieson 1984; Kirby 2007; Laukkanen 2000; Rasmussen & Sørheim 2006; Scott et al. 1998). More specifically, the focus of this category is not only on entrepreneurship, but also on entrepreneurs and small businesses, and the importance of these three to world economies with regards to social and economic change (Falkäng & Alberti 2000; Jamieson 1984; Kirby 2007; Scott et al. 1998).

Further to this, focus is also placed on the development of favourable attitudes to entrepreneurial situations and making students aware of the possibilities that can be derived from selecting entrepreneurship and the creation of new business ventures as a potential career (Fayolle 2007).

The second category, educating “for” entrepreneurship is focused on the preparing individuals to become entrepreneurs (Falkäng & Alberti 2000; Fayolle 2007; Hytti 2002; Hytti & O’Gorman 2004; Jack & Anderson 1999; Jamieson 1984; Laukkanen 2000; Rasmussen & Sørheim 2006; Scott et al. 1998; Solomon et al. 2002). Initiatives designed with these objectives in mind give students the necessary behaviour, knowledge, skills, techniques, and training to undertake entrepreneurial roles, specifically the skills needed for the creation, launch and management of business start-ups (Falkäng & Alberti 2000; Fayolle 2007; Jamieson 1984; Scott et al. 1998). The focus is also on preparing students to handle entrepreneurial situations and also the skills and knowledge to act and think as entrepreneurs in various situations and contexts, including creativity, innovation, intellectual property, commercialisation of technologies, and also business venture creation (Fayolle 2007; Kirby 2007).

The third category, educating “through” entrepreneurship is focused on providing opportunities to experience entrepreneurship as a part of the educational process through experiential learning programmes and activities (Fayolle 2007; Kirby 2007; Scott et al. 1998). Entrepreneurship initiatives could include educational options where students gain hands-on experience in entrepreneurship, for example, through computer or business simulations, entrepreneurship projects, or business-plan or venture competitions (Scott et al. 1998). Initiatives with these objectives are also focused on aiding students who are engaged in venture creation projects where students learn about the various aspects of the venture creation process, including introducing students to important individuals and potential partners, providing students with access to valuable and important resources, and coaching and mentoring opportunities (Fayolle 2007). Participating in experiential learning programmes provide students with business understanding and transferable enterprise skills (Kirby 2007).

The final category, educating "in" entrepreneurship looks at education or training that focuses on growth and development of established entrepreneurs (Jamieson 1984). This research study looks at the education of individuals who are generally new to the formal study of entrepreneurship, and not individuals who are already established as entrepreneurs. As a result, entrepreneurship educational initiatives whose objectives lie in the fourth category were not included in the study.

3.5.2: The Outcomes of Entrepreneurship Education Initiatives

The outcomes of entrepreneurship education initiatives are the actions and activities of students on completion of their participation in the initiatives (Matlay 2008), which can be divided into three types: social (learning to become an enterprising individual), economic (learning to become an entrepreneur), and pedagogical outcomes (learning to become an academic), and entrepreneurship initiatives can either possess one or more of these outcomes (Fayolle 2010; Fayolle & Gailly 2008).

Social outcomes are focused on the development of entrepreneurship in the society (Fayolle 2010), particularly the creation of an entrepreneurial culture which promotes the role and importance of entrepreneurship (Fayolle 2010; Fayolle & Gailly 2008). Social outcomes are also associated with students learning to become enterprising individuals. In this case, emphasis is placed on stimulating individuals' entrepreneurial spirit by first working on the entrepreneurial mindset and then on the demonstration of entrepreneurial actions (Fayolle 2010; Fayolle & Gailly 2008). The overall aim is to make students more entrepreneurial and doing this can only be achieved if individuals have a positive perception of entrepreneurship (Fayolle 2010; Fayolle & Gailly 2008). Entrepreneurship education can serve in this capacity by providing a scenario where individuals can acquire relevant knowledge that enables them to understand entrepreneurs and their roles, actions, values, attitudes, and motivations, which in turn may be able to create the positive perceptions of entrepreneurship needed (Fayolle 2010; Fayolle & Gailly 2008). Becoming an enterprising individual is about learning about entrepreneurship as a broad concept; this means that changes in attitudes, perceptions, and intention toward entrepreneurship are expected, highlighting the importance of having entrepreneur role-models in the learning environment (Fayolle 2010;

Fayolle & Gailly 2008). Initiatives with this outcome cater for a wide array of target audiences and participants from both the business and non-business fields (Fayolle 2010; Fayolle & Gailly 2008).

Economic outcomes are those focused on the activities that can generate economic benefits in society, either on the individual or the societal level, including the creation of new ventures or an increase in employment opportunities (Fayolle 2010; Fayolle & Gailly 2008). Economic outcomes are associated with students learning to become entrepreneurs, where one is either contemplating or is engaged in an entrepreneurial project and wants to improve this by receiving some training and support, or simply wants to learn about entrepreneurial situations and contexts (Fayolle 2010; Fayolle & Gailly 2008). Using a learn by doing approach, contexts and scenarios representing the real situations faced by entrepreneurs are taken into consideration, where individuals are expected to acquire skills, practical knowledge, techniques that enable succeeding and acting as entrepreneurs, and develop entrepreneurial competencies (Fayolle 2010; Fayolle & Gailly 2008). By becoming an entrepreneur, students will be able to solve problems by trial and error, learn from failure and being able to deal with emotions, and think, make decisions, and act according to the situation that arises, for example using prior entrepreneurial experience to aid in entrepreneurial behaviour (Fayolle 2010; Fayolle & Gailly 2008).

Pedagogical outcomes are those that enable potential entrepreneurs to learn about entrepreneurship (Fayolle 2010; Fayolle & Gailly 2008). These are associated with students becoming entrepreneur teachers and/or researchers, which means that the focus is on using theories and methods to help students to design research, gather data, and analyse data that answer questions about research issues in entrepreneurship (Fayolle 2010; Fayolle & Gailly 2008). The target students are typically doctoral candidates and higher research degree students, teachers, and other researchers who are expected to acquire theoretical and scientific knowledge (Fayolle 2010; Fayolle & Gailly 2008). The entire field of entrepreneurship is therefore seen as a research domain and employs various theories that can contribute to the development of entrepreneurship research (Fayolle 2010; Fayolle & Gailly 2008).

Therefore, whilst entrepreneurship initiative may differ according to their objectives, it is possible for the initiatives to achieve one or more of these outcomes.

3.5.3: Content of Entrepreneurship Education Initiatives

Entrepreneurship education requires a theoretical foundation which is used to determine the content that is taught and the way in which the content is taught (Fiet 2000b). It is important that entrepreneurship courses focus on the development of entrepreneurial skills, attributes, and behaviours (Kuratko 2003). In the courses, lecturers must teach more than the traditional business school skills; these courses must evolve in order to additionally include, for example, the development of communication skills, leadership, negotiation, problem-solving, time management, and creativity (Ray 1997). Entrepreneurship educational courses should also teach students the theories that show what is necessary to succeed (Fiet 2000a), and provide theory-based activities which teach entrepreneurial competencies (Fiet 2000a). Since the identification of opportunities is a capability that can be developed by individuals, entrepreneurship education is important in the development of opportunity identification (DeTienne & Chandler 2004; Fiet 2002). In fact, teaching the opportunity identification capability is a key component of entrepreneurship education (Lumpkin et al. 2004).

The available literature has revealed the presence of different types of entrepreneurship courses, for example, courses focused on new business start-ups (Gartner 1985), courses focused on the process of pursuing opportunities in a variety of contexts, including business start-ups (Brush et al. 2003; Hornsby et al. 1999; Hornsby et al. 1993), and courses focused on the management of small businesses (Brand et al. 2006). Courses focused on the pursuit of opportunities and business start-ups are concerned with the early stages of the entrepreneurial process, while courses focused on small business management are concerned with the management of existing firms and their growth (Brand et al. 2006). The differences in the types of entrepreneurship courses will therefore help to determine how the entrepreneurial educational initiatives are created, developed, and structured (Falkäng & Alberti 2000).

3.5.4: Entrepreneurship Education Initiatives

Entrepreneurship initiatives are typically organised in three ways. First, these initiatives can be more focused, with the entrepreneurship courses taught in one school and designed specifically for the students from that school, without the involvement of the faculty or students from other schools (Streeter et al. 2002). Second, there is a presence of entrepreneurship initiatives that are offered campus-wide, with courses taught in a number of different locations (Katz et al. 2014b). Third, there are initiatives that result from collaborations amongst an institution's schools and programmes, an approach which has been proven effective due to its similarities to the collaborative needs that characterise the rapidly changing world (Arthur et al. 2012).

There are also different types of educational options offered in entrepreneurship initiatives. Students can participate, for example, in full degree programmes with majors or concentrations offered in entrepreneurship, elective programmes such as minors or certificates in entrepreneurship, or graduate degree programmes in entrepreneurs (Morris et al. 2014). Students can also participate in stand-alone courses (Shartrand & Weilerstein 2012) or experiential learning and hands-on activities in order to experience the entrepreneurship process (Elia et al. 2011).

3.5.5: Entrepreneurship Education Initiatives Teaching Approaches and Methods

The teaching methods and approaches selected and used in entrepreneurship initiatives are dependent on the associated learning objectives (Fayolle & Gailly 2008; Hytti & O'Gorman 2004). Entrepreneurship education initiatives must be designed so that the academic learning is tied to what is happening in the real world; this means that the entrepreneurship education curriculum must be innovative, imaginative, and overall creative (Robinson & Haynes 1991). This tends to entail a combination of mindset shift, skill, development, and experiential learning (Wilson 2008).

A review of the entrepreneurship education literature has revealed different approaches to the teaching of entrepreneurship. In an examination of entrepreneurship education in Australasia, Crispin et al. (2013) identified that three general approaches are used in the effective teaching of entrepreneurship. First, entrepreneurship can be taught using a traditional “teaching” approach consisting of formal theory-based lectures and readings – in this approach, the instructor lectures to a classroom of students using material from the course textbooks and assesses what students have learned using tests (Crispin et al. 2013). A major criticism of the traditional approach is that the theoretical courses taught at tertiary-level academic institutions may not provide the complex reality that could potentially be gained from practical courses and projects (Chang & Rieple 2013). Furthermore, the use of a purely traditional lecture format may not be the most appropriate teaching approach as it is not completely representative of the entrepreneurial process, and may hinder the development of entrepreneurial attitudes and skills (Bennett 2006; Kirby 2004). Despite this, teachers rely on traditional teaching methods due to the fact that they can be easily accomplished and require less investment (Fiet 2000a, 2000b).

Second, entrepreneurship is also taught using a “trying” or active learning approach – a more hands-on teaching approach where students are actively encouraged to engage in and try their hands at entrepreneurship through hands-on projects and consulting-based approaches with teachers’ assessment of what students learn being more subjective (Crispin et al. 2013). One of the criticisms of this approach is the expressed level of doubt with regards to the abilities of educators who may be lacking in skills and experience to train those with entrepreneurial aspirations (Baumol 1983). Second, a learn by doing approach is viewed as being weak in theoretical foundations (Chang & Rieple 2013). Furthermore, the experiential methods may be costly and may not necessarily be aligned to the academic institution’s system of teaching (Mwasalwiba 2010). Despite this, experiential learning enables the learn by doing approach which provides a deeper understanding of entrepreneurship (Politis 2005), which is done either by gaining experiences in real-life situations (Hampden-Turner 2002), or through classroom-based discussions of case studies or hypothetical questions (Chang & Rieple 2013).

The first two types of teaching approaches are suitable for educating students with regards to entrepreneurship – the traditional methods provide students with the foundations of entrepreneurship and associated entrepreneurial actions, while the experiential learning methods, as demonstrated by the name, provide opportunities for students to interact with real-world practitioners, acquire entrepreneurial knowledge and skills, and stimulate attitudes (Arasti et al. 2012). To address the criticisms of the first two approaches, the third approach, a blended approach, has emerged which incorporates the strengths of both the teaching and trying approaches – in this approach, students are taught important entrepreneurship and business fundaments and then engage in entrepreneurial practical activities by applying the knowledge and skills learned in real-world situations, either through small business consulting or launching of new business ventures (Crispin et al. 2013; Fiet 2000b; Gibb 1993, 1996, 2002; Gorman et al. 1997; Hynes 1996). In fact, entrepreneurship education is distinguished from other forms of management education in that it incorporates experiential learning, which plays an important role in the educational initiatives (Greene et al. 2004). The benefit of the combined teaching and trying approach is that students are able to put what they have been taught into practice, which additionally allows this knowledge and skills to be reinforced and for students to identify any deficiencies in knowledge and skills they may possess (Crispin et al. 2013; Fiet 2000b; Gibb 1993, 1996, 2002; Gorman et al. 1997; Hynes 1996; Hynes & Richardson 2007). The combined approach also provides an opportunity to bring together individuals who have knowledge of the entrepreneurship theories and individuals who are entrepreneurs; in other words, opportunities to bring together entrepreneurship academics and practitioners (Chang & Rieple 2013).

The combination of traditional methods with experiential learning experiences helps to enhance the overall effectives of entrepreneurship education where students can engage in the overall learning process and reflect on what they have learned (Kolb 1984), which further helps to enhance students' perceived entrepreneurial self-efficacy (Duval-Couetil et al. 2016). The experiential activities are typically offered in one of two ways – through the experiential activities that are integrated into the requirements of entrepreneurship programmes or courses, or through extracurricular activities offered by the academic institution (Duval-Couetil et al. 2016). These experiential activities are representative of what happens in the real world, facilitate the occurrence of cross-functional learning, and facilitate the provision of the awareness, interest, and preparation that students require for a career in self-employment (Hynes 1996). Essentially, it is effective in the development and occurrence of entrepreneurial behaviour (Hartshorn & Hannon 2005; Lee et al. 2006; Politis & Gabrielsson 2009; Rae 2003). According to Crispin et al. (2013), the majority of entrepreneurship education initiatives are structured with a combined teach and try approach. However, since their work was based on entrepreneurship education in Australasia, it is important to find out if these approaches are used in other regions.

A variety of methods are used to teach entrepreneurship (Gibb 2002; Hynes 1996; Rideout & Gray 2013). The methods selected are dependent not only on the objectives of the initiatives, but also the target student groups (Hynes 1996; Hytti & O'Gorman 2004). To deliver entrepreneurial theoretical and conceptual frameworks, the methods used include traditional lectures, workshops, case studies, group discussions, guest speakers, web-based learning, and video recordings (Azim & Al-Kahtani 2014; Carrier 2007; Fayolle 2007; Fayolle & Gailly 2008; Gibb 2002; Hynes 1996; Lee & Wong 2007; Lonappan & Devaraj 2011; Mwasalwiba 2010; Solomon et al. 2002). To provide students with hands-on entrepreneurial practical experiences, which represent entrepreneurial realities and what entrepreneurs go through in the professional world, the experiential methods used include business and computer simulations, company and study visits, field trips, live projects, role-plays, games and competitions, team projects, internships in start-up and existing companies, individual written and oral presentations, business plan creation, business venture launches, elevator pitches and investment presentations, consultation and interviews with practicing entrepreneurs, and mentoring from experts and other individuals who possess entrepreneurial knowledge, skills, and experiences (Akola & Heinonen 2006; Azim & Al-Kahtani 2014; Carrier 2007; Duval-Couetil et al. 2016; Fayolle 2007; Fayolle & Gailly 2008; Gibb 2002; Hynes 1996; Lee & Wong 2007; Lonappan & Devaraj 2011; Mwasalwiba 2010; Solomon et al. 2002). If learning objectives relate to increasing the understanding of entrepreneurship and what it entails, suitable teaching methods could include traditional approaches such as lectures and seminars because they are able to transmit large amounts of information to a wide population in a relatively short amount of time (Hytti & O'Gorman 2004). If the objectives are associated with equipping students with entrepreneurial knowledge and skills which are applicable in a practical setting, then appropriate teaching methods are hands-on approaches which enable students to become directly involved in the entrepreneurial process, such as internships, small business consulting or industrial training (Hytti & O'Gorman 2004). If, however, the objectives are associated with the preparation of individuals to act as entrepreneurs, then the best technique is to engage students in an experimental approach which allows them to try entrepreneurship in a more controlled environment (Hytti & O'Gorman 2004), for example, through business simulations, role-playing, or the launch of student-run enterprises (Ahmad et al. 2004).

3.5.6: Cultural Considerations in Entrepreneurship Education Initiatives

Entrepreneurship education is present worldwide (Arthur et al. 2012; Blenker et al. 2011; Falkäng & Alberti 2000; Gibb 1993; Katz 2003; Kuratko 2005; Neck & Greene 2011; Solomon et al. 2002). There is similarity in content shared by entrepreneurship initiatives, although present in different countries around the world (Katz 2008). However, entrepreneurship educational initiatives should be specifically customised according to the national and cultural context of the country within which it will be situated and offered (Giacomin et al. 2011; Lee et al. 2006; Pittaway & Cope 2007).

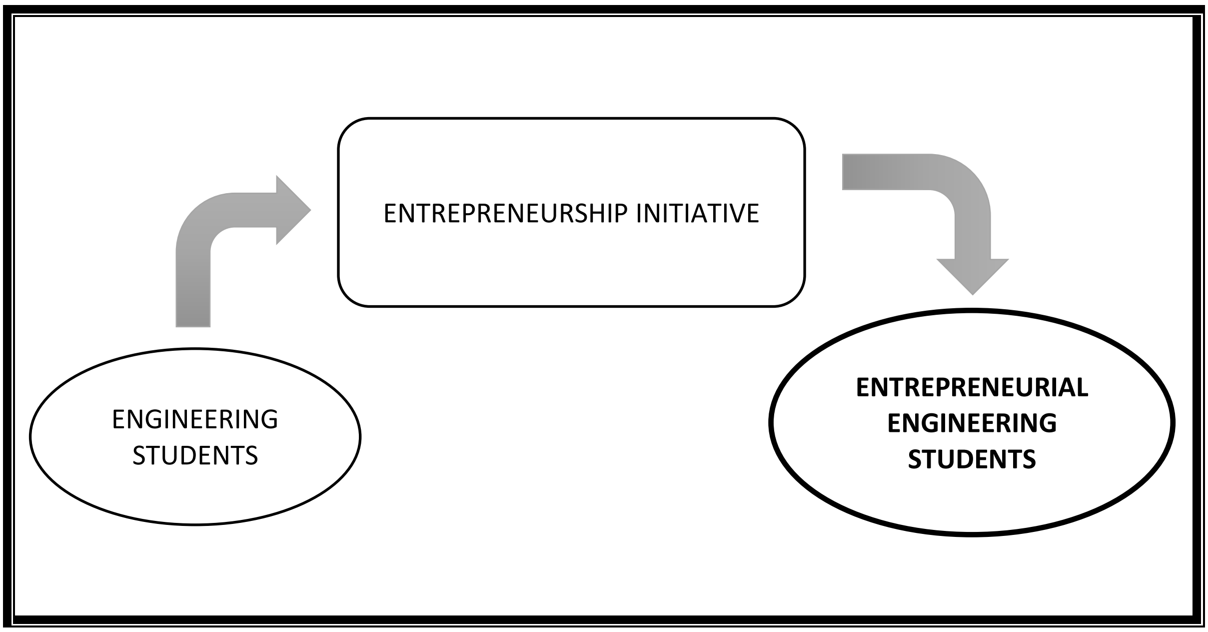
As a result, it is important that the structure, design, and development of entrepreneurship initiatives must take national differences into consideration (Lee et al. 2005; Pittaway & Cope 2007). For example, in Australia, the most commonly used approach is the teaching about entrepreneurship approach with entrepreneurship programmes built on a foundations of entrepreneurship and business planning courses (Crispin et al. 2013). In Europe, for example, entrepreneurship is more commonly offered in stand-alone courses which are primarily offered as optional or electives, as opposed to being integrated across the curriculum (Fayolle 2009). In these courses, the most commonly used teaching approach is the traditional teaching approach using lectures, despite research showing that methods involving more hands-on approaches with students trying entrepreneurship are more effective; and there is a greater emphasis placed on the start-up phase or creation of new ventures (Fayolle 2009). In the United States, as evidenced in an extensive review of the literature, if students are not majoring in entrepreneurship in their main degrees, they primarily learn about entrepreneurship through minor and certificate programmes which are added to their degrees (Byers et al. 2013).

Despite the similarities in the content of entrepreneurship initiatives, there are still regional differences which can prevent the global standardisation resulting instead in the development of regional standards (Katz et al. 2014a). An entrepreneurship initiative can be successful in one environment; however, there is no guarantee that an initiative can be successfully transferred to another environment (Nel et al. 2008). As a result, it is important for entrepreneurship initiatives to be relevant to the host environment in order to be successful (Nel et al. 2008). Awareness of regional differences helps to therefore determine how entrepreneurship educational initiatives are structured and aids in the structure and development of future initiatives.

3.6: Creating Entrepreneurial Engineering Graduates

Within Entrepreneurial Engineering initiatives, there is a close association between entrepreneurship education and innovation education with entrepreneurship and innovation being on opposite ends of the same process (Duval-Couetil & Dyrenfurth 2012). In this process, creativity, innovation, and product development are on one end of the spectrum and seen as the inputs to the innovation process; on the other end of the spectrum, the consequences of innovation including entrepreneurship and intrapreneurship in the form of, for example, new venture creation and enterprise management are on the other end as outputs (Duval-Couetil & Dyrenfurth 2012; Duval-Couetil et al. 2016). The basic premise of entrepreneurship initiatives for engineering students is presented in Figure 1.

Figure 1: The purpose of entrepreneurship education for engineering students



As displayed in Figure 1, the basic premise behind entrepreneurship education for engineering students is to include opportunities for engineering students to be educated about entrepreneurship with the aim of turning traditionally educated engineering students into engineering students with entrepreneurial knowledge, skills, competencies, and abilities (Polczynski & Jaskolski 2005).

Entrepreneurial Engineering educational initiatives for engineering students initiatives must be designed in order to arm engineering undergraduates with the strong technical skills, the abilities to communicate effectively and sell ideas, and the abilities to recognise and evaluate potential opportunities that are required by entrepreneurial engineers (Goldberg 2006). These initiatives combine fundamental technical courses with the courses and experiences necessary to stimulate entrepreneurial behaviour and activity, including, for example, innovation, intellectual property, leadership, and basic business courses such as finance and accounting (Polczynski & Jaskolski 2005). The initiatives also contain multidisciplinary courses and projects, all of which are focused on the generation of new opportunities, and also have strong links with businesses, investors, educational institutions, and individual entrepreneurs, all aimed at the successful creation of entrepreneurial engineering graduates (Polczynski & Jaskolski 2005).

Entrepreneurship education initiatives for engineering students vary and prepare students in a number of different areas in order to arm students with the knowledge and skills needed to identify and take advantage of opportunities (Byers et al. 2013). These areas include resource acquisition and leveraging; financial risk mitigation and management, strategic technology planning and development processes, new concept ideation, technology needs assessment, technology road mapping, intellectual property generation and protection, designing for end-users, effective communication, management and leadership of interdisciplinary teams, critical thinking, open-ended problem solving, identification of new business models, networking, venture or angel capitalisation, a broader way of thinking about and approaching entrepreneurship, and an understanding of basic business knowledge (Byers et al. 2013; Klein & Bullock 2006; Polczynski & Jaskolski 2005; Rideout & Gray 2013). This shows that these initiatives arm students with a combination of business, technical, interpersonal, and communication skills; and the abilities to act on opportunities, solve problems, and learn from failures (Zappe et al. 2013) which may encourage the students to pursue a career as an entrepreneur (Täks et al. 2014).

The increasing presence of entrepreneurship initiatives for engineering students has resulted in a diversity of entrepreneurship programmes, courses, and extracurricular activities that are open to engineering and science students (Shartrand et al. 2010). Examples of these initiative offerings include entrepreneurship concentrations and majors in undergraduate degrees (Besterfield-Sacre et al. 2011; Morris et al. 2014; Shartrand & Weilerstein 2012; Shartrand et al. 2010), elective programmes such as minors and certificate programmes, although these may not reach all engineering students (Besterfield-Sacre et al. 2011; Duval-Couetil et al. 2013; Morris et al. 2014; Peterfreund 2013; Shartrand & Weilerstein 2012; Shartrand et al. 2010), individual entrepreneurship courses offered both within and outside of their engineering programmes (Besterfield-Sacre et al. 2011; Duval-Couetil et al. 2016; Shartrand & Weilerstein 2012; Shartrand et al. 2010), experiential learning and extra-curricular entrepreneurship programmes and courses (Besterfield-Sacre et al. 2011; Duval-Couetil et al. 2010a; Duval-Couetil et al. 2016; Elia et al. 2011; Peterfreund 2013; Shartrand et al. 2010), multidisciplinary campus-wide entrepreneurship initiatives (Duval-Couetil et al. 2010a; Streeter & Jaquette 2004), specialised intensive, high-impact programmes, such as competitions and entrepreneurial residential living communities (Byers et al. 2013; Shartrand & Weilerstein 2012), and the integration of entrepreneurship-related knowledge and skills and content throughout engineering courses (Byers et al. 2013; Duval-Couetil et al. 2016; Duval-Couetil et al. 2013; Luryi et al. 2007; Shartrand & Weilerstein 2012).

The difference in the Entrepreneurial Engineering initiatives lies in the school within which the initiatives are situated and offered; with entrepreneurship education growing both within and outside the engineering discipline (Zappe et al. 2013). Entrepreneurial Engineering initiatives could be offered by one school at the institution, offered by the engineering school primarily targeting engineering students, result from a collaboration between different schools, or could be offered campus-wide for all students at the tertiary-level academic institution regardless of major (Duval-Couetil et al. 2010a, 2010b, 2011; Fayolle 2013; Shartrand & Weilerstein 2012). The schools responsible for these initiatives could also influence the type of initiative offered. For example, engineering and business schools join together to establish courses that will focus on product design and the development and commercialisation of new products, engineering schools offer minors, required entrepreneurial or innovation course sequences along with their original technically focused courses, or degrees that consist of broader technical context, or engineering schools collaborate with business schools to offer dual degrees that meet the combined engineering and entrepreneurial needs of students (Eisenstein 2010).

It must be noted that the type of Entrepreneurial Engineering initiatives offered could also differ depending on the country within which it is based and the specific culture of that country (Lee & Peterson 2000). In addition, the types of initiatives and the presence of these initiatives are all dependent on curricular constraints, for example, the time or space that is available in the engineering curriculum for elective programmes and courses and extra-curricular activities (Standish-Kuon & Rice 2002). This section shows that the presence of entrepreneurship initiatives in tertiary-level academic institutions ultimately differ and that there is no one particular type of initiative that will suit all students at all institutions (Duval-Couetil et al. 2016).

The next section discusses the Standish-Kuon and Rice (2002) typology which presents the different models or approaches used by tertiary-level academic institutions to educate engineering students about entrepreneurship.

3.7: How Tertiary-level academic institutions educate engineering students about entrepreneurship: The Standish-Kuon and Rice (2002) Typology

In an attempt to learn about how engineering students are educated about entrepreneurship, a review of the literature revealed the presence of one typology, which presented how tertiary-level academic institutions introduce entrepreneurship to engineering students – the Standish-Kuon and Rice (2002) typology. The literature review showed that the Standish-Kuon and Rice (2002) typology is the only conceptual framework that had been designed specifically to understand the different models or approaches that have been used to educate engineering students to be entrepreneurial. In recognition of the role that entrepreneurship education plays in creating Entrepreneurial Engineers and the fact that at the time there was insufficient understanding regarding the ways in which entrepreneurship was introduced to both engineering and science students, this study was undertaken in response to the lack of research available on the development of entrepreneurship in a field other than business. The purpose of the Standish-Kuon and Rice (2002) study was therefore to discover and identify the models used to introduce engineering and science students to entrepreneurship (Standish-Kuon & Rice 2002).

Using a qualitative method which involved a multiple case study, the researchers set out to explore how and why universities taught entrepreneurship to engineering and science students (Standish-Kuon & Rice 2002). The data for this study was collected in 1997, as a part of the founding of the National Consortium of Entrepreneurship Centers, from U.S universities that were selected based on four criteria:

- the universities were geographically diverse;
- the universities had a reputation for engineering and the sciences;
- the universities offered technological entrepreneurship initiatives and programmes; and
- each university had a center or program for entrepreneurship (Standish-Kuon & Rice 2002)

The final sample used in this study consisted of six American universities:

- Carnegie Mellon University;
- Rensselaer Polytechnic Institute;
- Stanford University;
- The University of California, Los Angeles;
- The University of Colorado at Boulder; and
- The University of Iowa.

A longitudinal study was used over a one year period, where the researchers collected data using a variety of qualitative techniques, including site visits, in-person interviews, telephone interviews, analysis of internal documents, and a follow-up survey (Standish-Kuon & Rice 2002).

The first objective of the study was to identify the goals of the universities' entrepreneurship programmes for engineering and science students or the reason the development of these programmes. The findings from the study revealed that the common primary goal was teaching entrepreneurship to engineering and science students, in particular to the students at the undergraduate level. The other goals identified included the development of the curriculum, the creation of new ventures, economic development, and the retention of faculty.

The second objective of the study was to determine how the universities taught entrepreneurship to the engineering and science students, i.e. the approaches used to teach entrepreneurship to engineering and science students. The researchers first found that the approach taken by the universities studied in educating engineering and science students about entrepreneurship was influenced by several factors, including the champion who developed the technological entrepreneurship initiatives and the assets available to support the initiative (for example, the availability of qualified faculty). The findings from the study revealed, as a consequence of these contextual influences, the presence of a typology which described three approaches that were used by universities to develop their technological entrepreneurship initiatives and teach entrepreneurship to engineering and science students. These three approaches included:

- the Business School model (Model A);
- the Engineering School model (Model B); and
- the Multi-school model (Model C).

In order to keep the models more generalized, the researchers decided not to differentiate based on the type of faculty and the type of course offerings. A summary of this typology is presented in Table 3.

Table 3: The Standish-Kuon and Rice (2002) typology showing how tertiary-level academic institutions introduce entrepreneurship to engineering and science students

Adapted from Standish-Kuon and Rice (2002)

The Standish-Kuon and Rice (2002) Typology			
Components of the Typology	**Model A: The Business School Model**	**Model B: The Engineering School Model**	**Model C: The Multi-School Model**
About the entrepreneurship programme	The programme is developed by the business school and can be designed to attract engineering students.	The programme is developed by the engineering school through a cross-pollination between the engineering and business schools (i.e. a sharing of knowledge and ideas)	This is a programme developed from a partnership involving the business school, the engineering school, and one or more technical schools.
The location of the entrepreneurship programme	The programme is housed in the business school	The programme is housed in the engineering school	The programme is housed in either the business school or the engineering school which tilts the balance tilts toward the particular school
The developers of the entrepreneurship programme's curriculum	The technological entrepreneurship curriculum is developed by the business school in collaboration with the engineering school	The technological entrepreneurship curriculum is developed by the engineering school and exists alongside the curriculum offered by the business school	The technological entrepreneurship curriculum is formed through the collaboration of the business school, the engineering school, and the other technical schools involved
Target students	Business, engineering, and possibly other non-business students	Engineering students	Students from each school in the partnership
The location where the entrepreneurship courses are taught	The business school but entrepreneurship faculty from the business school can also teach entrepreneurship courses in the engineering school	The engineering school but the business school can also reserve a number of spaces in its entrepreneurship courses for non-business students	The business school or the engineering school. Each entrepreneurship course will recruit a certain percentage of engineering students

As shown in Table 3, the entrepreneurship educational programmes for engineering and science students either primarily involved a business and engineering school collaboration or were designed by the engineering school specifically for the engineering students. However, the entrepreneurship educational programmes, as shown in Table 3, differed based on the location of the entrepreneurship educational programmes within the university. This showed that the location was the distinguishing factor that helped to identify the model or approach that a university used in teaching entrepreneurship to their engineering and science students.

The Standish-Kuon and Rice (2002) typology was referenced and accepted in a number of different research studies. Shartrand et al. (2008) described the research conducted by Standish-Kuon and Rice (2002) in discussing previous case-study research studies that were performed on entrepreneurship education in the engineering discipline. Similarly, Waters (2010) summarised Standish-Kuon and Rice's (2002) work in recognition of their research being one of the two studies published in the Journal of Engineering Education in the 2000s which focused specifically on entrepreneurship education programmes in the engineering discipline. In a more specific context, Soundarajan et al. (2013), in their description of an innovative entrepreneurship programme for engineering students offered at their institution, summarised the Standish-Kuon and Rice (2002) typology for the purposes of explaining the category that their programme belonged to. Previous research also cited this typology in the description of entrepreneurship programmes for engineering students. For example, Katz et al. (2014b) explained that Standish-Kuon and Rice (2002) provided an analysis to demonstrate how entrepreneurial efforts for engineering students at universities were organised; Duval-Couetil et al. (2015), in their discussion of the diversity of entrepreneurship programmes, presented and described the Standish-Kuon and Rice (2002) typology as a way of discussing that entrepreneurship programmes for engineering or science students are of different types; and Duval-Couetil et al. (2016) described the Standish-Kuon and Rice (2002) typology in their discussion of entrepreneurship programmes that have been designed for engineering and science students.

As illustrated, the use of the Standish-Kuon and Rice (2002) findings has demonstrated that research in entrepreneurship in an engineering context has previously been done. The above literature review provides examples of the types of studies that have been carried out, how entrepreneurship programmes for engineering studies are categorised, and an illustration of a programme and the features that show an example of one of the Standish-Kuon and Rice (2002) models. Although the research studies had different focal points, the combination has provided greater insight into the presence of entrepreneurship in the engineering field. The overall aim of the studies was to show and explain how tertiary-level academic institutions educated engineering students about entrepreneurship. Therefore, the use of the Standish-Kuon and Rice (2002) typology in different research studies has demonstrated that this typology is important in describing the approaches taken by academic institutions to educate engineering students about entrepreneurship. This supports the importance of the Standish-Kuon and Rice (2002) typology in generating a deeper understanding of how tertiary-level academic institutions educate engineering students about entrepreneurship, as well as a deeper understanding of stimulating entrepreneurship in an engineering context.

3.8: The Gap in the Literature

To be able to utilize entrepreneurship education effectively, tertiary-level academic institutions should be aware of the models or approaches that can be used to educate engineering students about entrepreneurship, as well as the available ways in which entrepreneurship education can be incorporated into the engineering curricula. Standish-Kuon and Rice's (2002) work provides an important and valuable foundation for understanding the types and range of educational models or approaches used to teach entrepreneurship in engineering schools, especially considering that the Standish-Kuon and Rice (2002) typology is presently the only one that has been identified in the literature. This typology is therefore essential to any research study which focuses on the role that tertiary-level academic institutions play in educating engineering students about entrepreneurship.

However, changes have occurred since the original Standish-Kuon and Rice (2002) study which must be taken into consideration. The primary change seen has been the increased demand worldwide for entrepreneurial engineers and a resultant increase in the presence of entrepreneurship educational initiatives for engineering students. Research has shown a growth in entrepreneurship educational offerings offered at tertiary-level academic institutions (Fretschner & Weber 2013; Kuratko 2005; Morris et al. 2014). Entrepreneurship education is no longer confined to the business school and students in a variety of disciplines are today being educated about entrepreneurship (Katz et al. 2014a; Katz et al. 2014b; Kuratko 2005). Research has also shown the presence of entrepreneurship education in areas such as agriculture (Mehlhorn et al. 2015; Zampetakis et al. 2013), physics (Arion

2013), arts (Kuratko 2005), and engineering and science (Byers et al. 2013; Kuratko 2005; Shartrand et al. 2010). In engineering, for example, entrepreneurship is one of the fastest growing academic areas with an increasing number of engineering students being educated about entrepreneurship (Besterfield-Sacre et al. 2013; Duval-Couetil et al. 2010b, 2011). In fact, despite entrepreneurship education being first seen in business schools, there is evidence that the presence of entrepreneurship in schools such as agriculture, engineering, and arts and sciences exists with minimum or no involvement from the business school (Katz 2003). In addition, research (for example Byers et al. (2013); Kriewall and Mekemson (2010)) has shown that external stakeholders and networks are playing greater roles in contributing to and influencing the combination of entrepreneurship and engineering. External stakeholders are in fact considered essential players in the creation of an entrepreneurship ecosystem (Isenberg 2011). There has also been an increase in entrepreneurship educational offerings has led to university-wide entrepreneurship education, where entrepreneurship education has become a vital component of the institution and its culture, allowing the institution to become more innovative, risk-taking, and proactive (Morris et al. 2014). These changes show that the field of Entrepreneurial Engineering has expanded, and this supports a need to gain further insight into how engineers are educated about entrepreneurship and therefore how Entrepreneurial Engineers are created.

As explained in section 3.4, the Standish-Kuon and Rice (2002) typology was developed based on data collected in 1997 and the primary characteristic used to differentiate the models was the location of the entrepreneurship programmes. Given the importance of Entrepreneurial Engineering, the growth in research in Entrepreneurial Engineering, the demand for Entrepreneurial Engineers, the importance of creating and developing entrepreneurship initiatives for engineering students which has led to an increased presence of these initiatives worldwide, the fact that the Standish-Kuon and Rice (2002) typology was developed based on data collected two decades ago, and the fact that two of the universities examined by Standish-Kuon and Rice (2002) were identified as evolving from one model to another by the end of the original study, made it necessary to revisit the topic of how tertiary-level academic institutions are creating Entrepreneurial Engineers by educating engineering students about entrepreneurship. More specifically, it became necessary to revisit the Standish-Kuon and Rice (2002) typology in order to determine if the typology still represented the models or approaches that are presently being used by tertiary-level academic institutions to educate engineering students about entrepreneurship, and whether it could be used to categorise the entrepreneurship initiatives that tertiary-level academic institutions develop for their engineering students. In addition, it became essential to obtain further details about each of the models or approaches which could help to identify how the models or approaches differed from each other, and provide information that can be used by tertiary-level academic institutions to create and structure entrepreneurship programmes for their engineering students. In the specific case of the engineering discipline, engineering schools are increasingly including entrepreneurship programs and courses; in fact, this inclusion is possibly one of the fastest growing areas curricula-wise (Duval-Couetil et al. 2011). Lastly, despite the presence of research into entrepreneurship education for engineering students in countries besides the United States, there is no documented evidence that shows studies similar to the Standish-Kuon and Rice (2002) study being performed outside the United States. This is something that must be taken into consideration, given the cultural differences that must be reflected in entrepreneurship education worldwide.

In summary, given the changes that have occurred in world economies and engineering education, it is necessary to determine if the Standish-Kuon and Rice (2002) typology is still applicable today. This is due to the growth in the presence of entrepreneurship initiatives for engineering students, and the approaches that are used. Furthermore, it is necessary to determine whether or not this typology needs to be updated to reflect today's entrepreneurship initiatives for engineering students. In order to utilise entrepreneurship education effectively, tertiary-level academic institutions need to be aware of the different ways in which entrepreneurship can be introduced to engineering students and integrated into the engineering curriculum.

3.9: The PhD Research Study

To address the gap in the literature, the overall aim of this PhD research study was to gain a deeper understanding of how tertiary-level academic institutions are educating engineering students about entrepreneurship and therefore the approaches that are being used to create Entrepreneurial Engineers. The focus was therefore placed on the Entrepreneurial Engineering activities of tertiary-level academic institutions offered at the undergraduate level in five countries: Australia, Canada, New Zealand, the United Kingdom, and the United States.

The PhD study had three specific objectives:

1. **To identify how tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States have addressed the need for engineering undergraduate students to develop entrepreneurial abilities;**

2. **To determine the typology developed based on the methods and approaches implemented and used by tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States to educate their engineering undergraduate students about entrepreneurship;**

3. **To determine the parameters and limitations of the proposed typology in terms of the typology's suitability for the classification of entrepreneurship initiatives used to create Entrepreneurial Engineers.**

To achieve these objectives, the PhD research study was structured to seek answers to the following research questions:

- **Research Question #1**: How have tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States addressed the need for engineering undergraduates to develop entrepreneurial abilities?

- **Research Question #2**: What is the typology, resulting from the methods and approaches, which has been implemented and used by tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States to educate their engineering undergraduates about entrepreneurship?

- **Research Question #3**: What are the parameters and limitations associated with the proposed typology with respect to its suitability for the classification of entrepreneurship education initiatives used to create Entrepreneurial Engineers?

The research examined Entrepreneurial Engineering initiatives offered at the undergraduate level because entrepreneurship education at the undergraduate level has significantly grown, with students in a variety of disciplines being able to participate in entrepreneurship majors, entrepreneurship minors, and entrepreneurship certificates (Brooks et al. 2007). This has occurred based on the fact that the earlier students are introduced to entrepreneurship and innovation, the higher the level of intention towards entrepreneurial careers in the future (Wilson 2008). Entrepreneurship education for engineering students has been increasingly offered at the undergraduate level. At this level of the tertiary level academic career, engineering students are able to learn about the entrepreneurship discipline during a formative time in their engineering education (Polczynski & Jaskolski 2005). When engineering students participate in entrepreneurship initiatives at the undergraduate level, they gain additional insights including understanding of customer needs, designing for the end-users, communicating effectively, thinking critically, solving problems, working in and managing interdisciplinary teams, and business fundamentals (The U.S. National Academy of Engineering 2004).

The five countries included in this study – Australia, Canada, New Zealand, the United Kingdom, and the United States – are all at the same stage of economic development (Kelley et al. 2016). The United States was first selected. The United States was ranked as the leading entrepreneurial country on the Global Entrepreneurship Index list (Acs et al. 2016). It is seen as an innovation-driven economy with a strong entrepreneurial ecosystem which facilitates the occurrence of entrepreneurial activity (Regele & Neck 2012). Companies present in these economies must compete (and therefore gain competitive advantage) by producing new, different and innovative goods and services using sophisticated production processes (Schwab & Sala-i-Martin 2014). The United States was also selected because it is seen as the world leader in entrepreneurship education (Gürol & Atsan 2006). In addition, it was the first country selected due to the fact that the original Standish-Kuon and Rice (2002) typology was created and developed using data collected from universities in the United

States. The need for engineers to possess multidisciplinary skills has been acknowledged and addressed in the United States, with the Accreditation Board for Engineering and Technology, Inc. (ABET), the board that accredits post-secondary education programs in the areas of applied science, computing, engineering, and engineering technology, presenting the Engineering Criteria 2000 [EC2000], a reformed version of the original accreditation criteria in 2000 (Felder & Brent 2003; Soundarajan 1999). This reformation of accreditation criteria became necessary due to the fact that the skills taught to engineering students at that time were not in line with the needs of Industry (Prados et al. 2001), and because of the demand for engineering students to possess the skills necessary to tackle the modern-day engineering arena and occupy the more extensive range of job options (Shuman et al. 2005). The EC2000 criteria were designed to address the need for engineers to acquire both technical and entrepreneurial skills (Felder & Brent 2003). Five of the eleven EC2000 criteria are aimed at the development of entrepreneurial abilities; specifically, designing in order to meet desired needs (3c), working on multidisciplinary teams (3d), solving problems (3e), communicating (3g), and possessing the knowledge and understanding of engineering and its impact in a global and societal context (3h) (Ohland et al. 2004b). The EC2000 criteria has resulted in institutions implementing programs that stimulate and develop entrepreneurial attributes and behaviours in engineering and science graduates in response to the demand for the new type of engineer (Dabbagh & Menascé 2006).

Like the United States, Australia, Canada, New Zealand, and the United Kingdom are also viewed as innovation-driven economies with strong, innovative, entrepreneurial ecosystems (Kelley et al. 2016). In addition to the United States, which was identified as the world's most entrepreneurial country, Australia, Canada, and the United Kingdom were ranked as the top entrepreneurial English-speaking countries, ranking 2nd (Canada) 3rd (Australia), and 9th (the United Kingdom) on the Global Entrepreneurship Index list (Acs et al. 2016). In Australia, the small business sector – consisting of small and medium-sized enterprises (SMEs) – is a significant part of the national economy, accounting for 99% of all Australian businesses (Organisation for Economic Co-operation and Development (OECD) 2010). There is also an increasing presence of entrepreneurship education programmes in Australia (Kirby 2004). In Canada, which is also an entrepreneurial country, there has been an increase in engineers who are seeking entrepreneurial opportunities (Solymossy & Gross 2015). The

United Kingdom has also significantly invested in the promotion of entrepreneurship in order to enhance innovation and economic growth (Lucas & Cooper 2006). In line with this promotion is an increasing presence of entrepreneurship education programmes in the United Kingdom (Kirby 2004). New Zealand was also included in this research study due to the country being one of the most entrepreneurial countries in the world, and entrepreneurs play a significant role in creating a prosperous New Zealand (Nel et al. 2008). In fact, New Zealand is known for creating, preparing, and exporting large numbers of entrepreneurs (Arthur et al. 2012). Furthermore, Like the accreditation criteria of ABET, the accreditation criteria of the main engineering accreditation boards in the four countries – Engineers Australia, Engineers Canada, the Institution of Professional Engineers New Zealand (IPENZ), and Engineering Council U.K. – showed that engineering students required both technical and non-technical skills.

The selection and review of tertiary-level academic institutions and their entrepreneurship educational initiatives for undergraduate engineering students in Australia, Canada, New Zealand, the United Kingdom, and the United States has allowed for the use of the original Standish-Kuon and Rice (2002) study as a useful foundation. This helps to expand on the original study and its findings in order to reflect on present-day entrepreneurship initiatives for engineering students.

The next chapter, Chapter 4, will present a more detailed discussion of the methodology associated with the research study.

Chapter 4: Methodology

4.1: Introduction

Chapter 4 outlines the methodology for this doctoral research study. It first presents the philosophical framework associated with this research, and then continues with a discussion of the research approach and research design used. The chapter concludes with a discussion of the quality of data and the ethical issues that had to be considered.

4.2: The Philosophical Framework

The purpose of this research was to investigate how tertiary-level academic institutions educate engineering undergraduates about entrepreneurship. The objective was to develop a typology which identified and described the models that were used by tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States to create engineering graduates with entrepreneurial abilities. The Standish-Kuon and Rice (2002) typology, which was developed from data collected from universities in the United States, was used as the foundation for the new typology. As a result, the overall objective of this research was to potentially extend and enhance an existing theory in lieu of generating a new theory.

The philosophical framework for the research includes the philosophical paradigm, ontology, and epistemology of the study. A philosophical paradigm is used by researchers to understand reality, build knowledge, and gather information about the world (Tracy 2012). The use of a philosophical paradigm guides research by showing how the world is perceived and ultimately determining the research approach that will be used (Sarantakos 2013). In addition, the methodological approaches of a research study generally have an ontological standpoint and are set in an epistemological tradition (Stokes 2011). First, the ontology asks about the nature of research or what the research focuses on (Creswell & Plano Clark 2011; Sarantakos 2013; Saunders et al. 2007; Teddlie & Tashakkori 2009; Wilson 2010). In other words, the ontology addresses the assumptions that researchers hold with regards to the world and how it operates. Epistemology, on the other hand, looks at the kind of knowledge that is considered important and consequently what the research is looking for (Creswell & Plano Clark 2011; Sarantakos 2013; Saunders et al. 2007; Teddlie & Tashakkori 2009; Wilson

2010). Taking ontological assumptions into consideration, the world and reality can be perceived as being either objective or subjective. Researchers who hold the objectivist view see social entities as separate from social actors (Saunders et al. 2007; Wilson 2010). This means that these researchers view the world as something that distinctly exists, regardless of people, their actions, and their activities (Eriksson & Kovalainen 2008). Objectivist researchers tend to use quantitative research methods (Bryman & Bell 2011). Alternatively, researchers who hold the subjectivist view see the world as being developed from social phenomena created from the multiple actions and perspectives of social actors (Saunders et al. 2007; Wilson 2010). This means that these researchers view the world as something that is based upon actions, perceptions, and experiences that could differ from one person to the next and could potentially change over time (Eriksson & Kovalainen 2008). In comparison to objectivist researchers, subjectivist researchers generally use more qualitative research methods (Bryman & Bell 2011). With regards to the epistemological assumptions, objectivist or subjectivist views can also be taken. In the case of the former, researchers see the knowledge created and data that the research is looking for as existing externally to and being independent from the actions of the researcher (Stokes 2011). In the case of the latter, researchers see the knowledge and data existing due to the involvement of the researcher (Stokes 2011). The ontology and epistemology positions are important to know because the design structure chosen to achieve the objective of the research study and the research methods or the way in which the research is conducted are both dependent on the ontological and epistemological perspectives selected by the researcher (Sarantakos 2013). As a result, having a philosophical paradigm and subsequently an ontological and epistemological stance are essential in guiding the way that a research study is conducted.

Of the different philosophical paradigms available, two were selected for this research. The first paradigm was the Pragmatist paradigm. The Pragmatist paradigm is associated with the belief that there is no need to make a choice between qualitative and quantitative worldviews (Teddlie & Tashakkori 2009). It focuses on the research problem (as opposed to method) and uses all available approaches to develop a greater understanding of this problem (Creswell 2014; Onwuegbuzie et al. 2009; Saunders et al. 2007). Adoption of the pragmatist view requires a focus on research and its consequences, the research questions instead of the method; and seeks to utilise multiple data collection methods to address the problem being studied (Creswell & Plano Clark 2011). Researchers who follow the pragmatist view generally believe that research is neither purely objective nor subjective but instead lies on a spectrum between the two (Teddlie & Tashakkori 2009); or in other words, pragmatist researchers adopt both objective and subjective views.

For this research study, the pragmatist approach was appropriate. To learn about how tertiary-level academic institutions are educating engineering undergraduates about entrepreneurship and then be capable of presenting an overall picture of how this was being done at these institutions required a combination of different types of data and, as a result, different methods and approaches to acquire the relevant data. The important elements that had to be taken into consideration were ensuring that the relevant research questions were addressed, and that the most suitable methods were applied in order to address each question. As a result, the focus on the research questions coupled with the acquisition of multiple forms of data, methods, and approaches are in line with pragmatist views. Although the use of a pragmatist approach traditionally means that researchers generally use both objectivist and subjectivist views, in this research, an objectivist stance was adopted. This was because the nature of the research opportunity required an understanding of how tertiary-level academic institutions were educating students about entrepreneurship. Obtaining the overall picture required knowledge of the activities at the academic institutions; it did not require the involvement and interaction of the researcher to make sense of what was occurring at the institutions with regards to the entrepreneurship education of engineering undergraduates.

The second paradigm selected was the Positivist paradigm. In this paradigm, researchers believe that there is a single true reality existing in the world and that is waiting to be discovered (Tracy 2012). Positivist researchers conduct research in order to acquire the necessary data and knowledge that can clearly represent the phenomenon that is being examined (Tracy 2012). In addition, these researchers believe that the tools which are used to conduct the research can produce information that can be reproduced and replicated under similar research conditions (Lapan et al. 2011). Furthermore, positivist researchers tend to observe, as opposed to interact with the phenomenon being studied, and have a preference for being deductive and testing existing theories as opposed to inductively deriving new theories from the phenomenon under research (Lapan et al. 2011). The positivist paradigm is traditionally associated with quantitative research due to the association with deductive research and the testing of theories (Bryman & Bell 2011). However, a positivist view in qualitative research relates to the acquisition of a sample which allows the question of “what is happening here?” to be addressed (Tracy 2012).

A positivist stance was adopted for three reasons. First, based on the research objectives and approach, there was no requirement for the researcher to be involved with the research which eliminated any influence on the data and knowledge acquired during the research process. Second, taking a positivist stance, as explained earlier in section 4.2, is generally associated with deductive research – which involves the testing of theories. In this research study, the original typology developed by Standish-Kuon and Rice (2002) was used as the framework for investigating the models presently being used to educate engineering undergraduates. As a result, the original typology was tested to determine whether it was still representative of the models being used. Finally, a positivist stance was appropriate for the qualitative component of the research. The aim of this phase was to identify the models being used, which was conducted using data from acquired from websites. Obtaining this data allowed for a picture of the reality to be generated without having to interact with social actors. As a result, it addressed the question associated with positivism in qualitative research – i.e. the question of “what is happening here?”

4.3: The Research Approach

As explained in section 3.9, this doctoral research study had three specific objectives:

1. To identify how tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States have addressed the need for engineering undergraduate students to develop entrepreneurial abilities;

2. To determine the typology developed based on the methods and approaches implemented and used by tertiary-level academic institutions in Australia, Canada,

New Zealand, the United Kingdom, and the United States to educate engineering undergraduate students about entrepreneurship;

3. To determine the parameters and limitations of the proposed typology in terms of the typology's suitability for the classification of entrepreneurship initiatives used to create Entrepreneurial Engineers.

Based on the study's objectives, this research study first possessed exploratory characteristics. Exploratory research is the type of research which involves becoming familiar with a particular research topic by using relevant approaches to investigate an area that is either new or where minimal research exists (Babbie 2014; Wilson 2010). It is also the type of research that allows for researchers to become familiar with the problem, concept, or phenomenon that is being studied (Singh 2007). Exploratory research is useful, given that it is the initial research that forms the foundation for future research to occur (Singh 2007). In the exploratory component of the research study, the aim was to identify the models used by tertiary-level academic institutions to educate engineering undergraduates about entrepreneurship. Furthermore, exploratory research was useful for describing the models that were used by these academic institutions. This exploratory purpose was seen in the form of categorisation. Categorisation is a research process that entails the formation of a typology that consists of a set of names, boxes, or other entities which the phenomenon being studied can be separated into (Walliman 2010). The identification of the models used in each of the five countries led to the development of an overall typology, in addition to country-specific typologies.

The study also possessed descriptive characteristics. Descriptive research studies involve the process of observing and then describing what was observed (Babbie 2014; Wilson 2010). In descriptive research, the aim is to produce descriptive data relating to the population under investigation, but not to identify any cause-and-effect relationships that may exist within the population (Singh 2007). Furthermore, it also involves the production of descriptive statistics, representing the frequency or number of times that things occur in the population (Singh 2007). In the descriptive component of the research study, descriptive statistics were used to create and present overall descriptions of each of the models, and ultimately the typology.

The focus of this research, despite the identification of models, the development of a typology, and a description of the models and typology, was however more deductive. Taking a deductive research approach refers to the application of theories in the real world in order to determine whether or not they hold true (Bryman & Bell 2011). The deductive approach applied in this research project involved determining whether the Standish-Kuon and Rice (2002) typology represented the models used by academic institutions to educate engineering undergraduates about entrepreneurship. The aim was therefore to identify if any of the models of the Standish-Kuon and Rice (2002) typology were presently being used, or if changes had occurred since the development of the original typology. In other words, a new theory was not being identified – instead the applicability of the existing theory was being tested. In the descriptive component, on the other hand, the aim was to provide details of each of the models used by these institutions. Both the qualitative and quantitative descriptive details provided knowledge about what was common, or uncommon, within each of the models. Therefore, the research was therefore primarily deductive; however, in evaluating the applicability of the existing theory, inductive reasoning was necessary in order to address any changes that had to be made to the existing theory.

Given that the research had two different purposes, a combination of data types and methods were required. This is because exploratory research mainly uses qualitative research approaches, while descriptive research can use either qualitative or quantitative research approaches (Wilson 2010). As a result, it was recognised that a mixed methods study would be the most appropriate research approach. A mixed methods research approach is one where both qualitative and quantitative data are collected and analysed based on the research questions. A number of designs exist. In the first design, both types of data are mixed by combining them sequentially either by having one type of data build on the other type or inserting one type within the other. Alternatively a second approach prioritises one or both types of data whereby the methods employed are used in either a single or multiple phase research study, and the methods are combined in a research design that guides how the research is conduced (Creswell & Plano Clark 2011).

A mixed methods study with multiple research strategies enables the exploration of a research topic from various angles and allows for an overview or overall picture of a topic to be presented (Henn et al. 2006). In other words, with a mixed methods study, a more comprehensive picture of the research area under investigation can be acquired if both qualitative and quantitative research methods are employed (Bergman 2008; Given 2008). Furthermore, using both qualitative and quantitative research methods allows for different research questions to be addressed (Bergman 2008). This type of research is also suited for cases where the overall research objectives are best addressed with multiple phases or projects (Creswell & Plano Clark 2011). In addition, the findings of one type of research can potentially be enhanced by adding the findings of another type (Bergman 2008), resulting in a beneficial combination.

A mixed methods research approach was the most suitable approach for this research study. To describe how academic institutions educate engineering undergraduates about entrepreneurship and learn about the models presently being used, the relevant research questions were best addressed using qualitative and quantitative research methods. In addition, the combination of data and knowledge acquired from both research types helped to provide missing information about the models and their content, addressing both the explorative and descriptive purposes of the research.

4.4: The Research Design

The research design was based on the fact that a mixed methods research approach was selected. Section 4.4 provides details about how the research design was derived and provides further information about each phase of the research design.

4.4.1: The selection of the mixed methods research design

The first step taken in creating the mixed methods research design used in this study was the selection of the relevant perspective associated with the design. The perspectives associated with mixed methods research ultimately guide researchers in the strategies and designs best suited to the research objectives (O'Leary 2014). Taking the pragmatist approach into consideration, the perspective selected was the Question-Driven perspective. Unlike the two other perspectives associated with mixed methods research, which either emphasise qualitative or quantitative research, this perspective places focus on the research questions as opposed to the qualitative or quantitative components (O'Leary 2014). The adoption of the Question-Driven perspective meant that relevant strategies were selected to acquire the necessary data needed to address the research questions(O'Leary 2014). Although addressing the research questions may result in either the qualitative or quantitative component becoming more dominant than the other, the focus was primarily on what was necessary to obtain the relevant data. Furthermore, this perspective encompasses a wider range of research designs, including those associated with those best suited to the qualitative-emphasised or quantitative-emphasised perspectives (O'Leary 2014). The general idea behind the Question-Driven perspective acknowledges both the strengths and weaknesses of the qualitative and quantitative research approaches and doesn’t value one research approach over the other (O'Leary 2014).

The design of the mixed methods research study considers three specific dimensions: the level of mixing, time orientation, and the emphasis of approaches (Leech & Onwuegbuzie 2009). The level of mixing refers to whether the qualitative and quantitative portions of the study were mixed once both types of data had been separately collected and analysed; or fully mixed, where qualitative research and quantitative research were mixed across the various components of a single research study (Leech & Onwuegbuzie 2009). In this research, the aim was to first collect and analyse qualitative and quantitative data in separate phases, and then subsequently combine the findings from both data types in order to paint an overall picture that demonstrated the models used to educate engineering undergraduates about entrepreneurship. As a result, this research design required partial mixing.

Time orientation, the second dimension, refers to whether the qualitative and quantitative components of the research occurred either concurrently, where the data in each component was collected and analysed at the same time; or sequentially, where qualitative and quantitative components occurred one after the other (Leech & Onwuegbuzie 2009). For this research study, each phase had to occur sequentially. This was because in each phase, the data had to be collected and analysed before the subsequent phase could be executed.

The final dimension focuses on whether the qualitative and quantitative components were equally important in the answering of the research questions, or whether one component had significantly higher priority in comparison to the other component (Leech & Onwuegbuzie 2009). For this research study, the qualitative component was comprised of two of the three phases of the research study, with the quantitative phase serving to obtain data which supplemented the findings from the qualitative component.

Taking each dimension into consideration, the design selected for this research study was a Partially Mixed Sequential Dominant Status design (Leech & Onwuegbuzie 2009). This design is for studies with multiple phases where the phases, including the collection and analysis, occur sequentially, with greater emphasis being placed on either the qualitative or quantitative component, and the data from the two components are subsequently mixed at the interpretation stage (Leech & Onwuegbuzie 2009).

4.4.2: The structure of the mixed methods research design

Once the research design was selected, data collection processes were developed. This resulted in the design of a multiphase study consisting of three phases. The multiphase design is presented in Figure 2.

Figure 2: The Phases of the PhD Research Study

Objectives of the Research Study

To identify how tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States have addressed the need for their engineering undergraduate students to become entrepreneurial [*Objective #1*]

To determine the typology developed based on the methods and approaches implemented and used by tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States to educate their engineering undergraduate students about entrepreneurship. [*Objective #2*]

To determine the parameters and limitations of the proposed typology, in terms of the typology's suitability for the classification of entrepreneurship initiatives used to create Entrepreneurial Engineers [*Objective #3*]

Phase One

Content analysis of data regarding entrepreneurship initiatives for engineering undergraduates offered by tertiary-level academic institutions in the United States.

Purposes

(1) To determine whether or not the Standish-Kuon and Rice (2002) typology was still applicable to the categorisation of entrepreneurship initiatives for engineering undergraduates at U.S. tertiary-level academic institutions.

(2) To determine the typology of models presently being used by U.S. tertiary-level academic institutions to educate engineering undergraduates about entrepreneurship.

Phase Two

Content analysis of data regarding entrepreneurship initiatives for engineering undergraduates offered by tertiary-level academic institutions in Australia, Canada, New Zealand and the United Kingdom.

Purposes

(1) To determine the models used by tertiary-level academic institutions in Australia, Canada, New Zealand, and the United Kingdom to educate engineering undergraduates about entrepreneurship.

(2) To determine whether or not the typology identified in Phase One could be applied in other countries.

Phase Three

Administration of online questionnaires to engineering school administrators and analysis of resultant data to gain additional insight into entrepreneurship initiatives for engineering undergraduates.

Purposes

(1) To capture information from institutions not identified in Phases One and Two.

(2) To confirm the presence of the models identified.

(3) To obtain additional data needed for descriptions of each model.

As highlighted in Figure 2, both qualitative and quantitative data collection approaches were utilised to address the different research processes. Besides the research questions, the use of both a qualitative and quantitative research approach was selected due to the potential benefits that can be achieved from the combination of data collection methods available through a mixed methods approach (De Leeuw 2005).

A qualitative approach to data collection was taken in Phases One and Two. Undertaking the qualitative component before the quantitative component allows existing research to be identified and collected in order to make effective use of a researcher's resources and time (Mohapatra et al. 2014). In this research study, the qualitative component allowed for the collection of secondary data. Secondary data is data that exists in other forms which was primarily collected for some purpose other than that of the research (Lancaster 2007; Stokes 2011). It is also typically the starting point in the data collection process and the first type of data to be collected (Lancaster 2007). The qualitative component provided insight into the available data on the models used by academic institutions to educate engineering undergraduates about entrepreneurship. This reduced the need for certain data to be gathered in the form of primary data from the academic institutions, which in turn saved time and money (Mohapatra et al. 2014).

In the two qualitative phases, as shown in Figure 2, the secondary data – in this case, available data on the entrepreneurship initiatives for engineering students – was collected from webpages, using similar approaches to those used by Béchard and Grégoire (2007) and Mazzarol (2014), and copied into Microsoft Word documents. These documents were then subjected to content analysis. Content analysis involves the examination or analysis of the written text in documents using, for example, specific words, themes, and characters (Bloor & Wood 2006; Mohapatra et al. 2014). In this process, the frequencies of certain words, themes, or phrases that exist within written text or a number of documents are determined (Bloor & Wood 2006). The content analysis process is typically associated with quantitative techniques (Bloor & Wood 2006). However, the process can employ both quantitative and qualitative research techniques (Tharenou et al. 2007). In the case of this research study, the content was analysed using a qualitative approach. As such, the adoption of a qualitative content approach was appropriate given the research aims, which required the identification of specific words and themes drawn from academic institutions' webpages to classify these entrepreneurship initiatives according to the relevant models.

Content analyses generally use a positivist and objective approach, and are concerned with the surface meaning of content in lieu of interpretive meanings (Bloor & Wood 2006). This again aligned with the aims of this research study, whereby the data was taken at face value and did not require interpretation to generate the required understanding. Content analysis is conducted either manually or on a computer, although a similar approach can be taken in either case (Tharenou et al. 2007). For this research study, the content analysis was performed both manually and on a computer, with the manual content analysis performed in Phase One and the computer content analysis performed in Phase Two. In performing the content analysis of the qualitative data, a template analysis was used. A template analysis is a type of content analysis used to organise data according to a set of predetermined categories or themes which are related to the research questions and the topic being investigated (Crabtree & Miller 1992). This template analysis was conducted based on the Standish-Kuon and Rice (2002) models, with the typology serving as the analytical framework for the organisation of the data.

As indicated by Figure 2, In Phase Three of the research study involved the collection of primary quantitative data. Primary data is data that has been collected by the researchers for the purposes of the project under investigation (Stokes 2011). This means that the existence of this data is dependent on the execution of the study and the research process (Lancaster 2007). For this research study, the primary data was collected in the final phase of the study because it served to enhance the findings of Phases One and Two by addressing and filling the gaps in knowledge within the findings stemming from the qualitative content analysis. Primary data is collected using a number of different techniques including experiments, interviews, observation, and surveys (Lancaster 2007). For this research, surveys in the form of questionnaires were administered to acquire the relevant data. The questionnaires were administered via the online platform Survey Monkey. Emails were then sent to potential respondents with links to the questionnaire. Survey Monkey was suitable since it allowed for the responses to be collected in Microsoft Excel spread sheets, which were then imported into statistical software for analysis. Further details about each of the phases are provided in sections of 4.5, 4.6, and 4.7.

4.5: The Research Study: Phase One

In Phase One, the objective was to identify the models used by tertiary-level academic institutions within the United States to educate engineering undergraduates about entrepreneurship. This section provides information about the sample, data collection process, and data analysis process used Phase One.

4.5.1: The Phase One Sample and Data Collection Process

In Phase One, the sample determination and data collection processes occurred simultaneously. To determine the Phase One sample, it was first necessary to identify the population and the associated sample frame from which the sample had to be selected. The population is the total number of subjects that is of interest in a research project (Veal 2005; Walliman 2010). The population for Phase One was defined as tertiary-level academic institutions in the United States that offer entrepreneurship education to engineering students at different tertiary-levels. The sample frame for a research study, on the other hand, is the subset of a population which is eligible for inclusion in the required sample (Given 2008). In other words, the sample for the research study is selected from the sampling frame. Based on the U.S. context, the sample frame for this research project included tertiary-level academic institutions in the United States that offered entrepreneurship education to engineering students at the undergraduate level.

Next, non-probability sampling methods were used to determine the sample. Non-probability sampling is where researchers choose the members of the sample for the project using non-random means (Walliman 2006, 2010). In this type of sampling, the researcher doesn't use probability in selecting members for the sample and is therefore unaware of the probability of a subject's inclusion in the sample (Babbie 2016; Bloor & Wood 2006; Tharenou et al. 2007). Non-probability sampling is typically associated with qualitative research, where researchers use their judgement to select their sample (Given 2008). This type of sampling was appropriate for Phase One, whereby data and knowledge had to be acquired from specific academic institutions. As a result, certain criteria had to be met for inclusion in the overall sample.

The type of non-probability sampling used was purposive sampling. Purposive sampling is the approach taken where researchers select participants for the research based on predetermined criteria which are perceived as being relevant to the addressing of the research question (Bloor & Wood 2006; Given 2008; Tharenou et al. 2007; Walliman 2006). To identify the Phase One sample, the decision was made to examine the entrepreneurship education initiatives offered at the institutions that had ABET-accredited programmes because the Criterion 3 (a-k) of the ABET EC2000 criteria is useful for the promotion of entrepreneurship education, and in particular entrepreneurial engineering (Nichols & Armstrong 2003). In addition, the technical and non-technical skills that are reflected in Criterion 3 can be equated to the skills that are generally acquired through entrepreneurship education – for example, the ability to address real world problems, the perception of opportunities, the abilities to lead others, communicate effectively, and work in multidisciplinary teams, and the capabilities to be flexible in periods of uncertainty and deal with risk and failure (Duval-Couetil et al. 2015). Furthermore, there is literature (for example, Nichols and Armstrong (2003) and Duval-Couetil et al. (2015)) that demonstrates that engineering courses and projects include entrepreneurial knowledge and entrepreneurial competencies in order to meet the ABET criteria. As these institutions were most likely to offer entrepreneurship education initiatives to their engineering students, they exhibit the phenomena of interest in this study.

To obtain the list of institutions, the ABET website (www.abet.org) was first visited. Once on the website, the link '*Find an ABET-Accredited Program'*, which was located at the top left-hand side of the home page of the website, was clicked on. Under the '*Quick Search*' option, that was seen on the page, that appeared once the previous link was clicked on, the following were selected:

- Under '*Program Name*', *Bachelor (4-year)* (the two other options had to be de-selected)
- Under '*Country*', *United States*
- Under '*State/Region*', *--ALL--*

This produced member lists of institutions with accredited undergraduate programmes in different areas of engineering. Conducted in January 2015, this process identified a total of 414 institutions offering ABET-accredited undergraduate programmes.

Following the compilation of this list, the webpages of these institutions were visited to identify evidence of entrepreneurship programmes, courses, and activities that were available to engineering undergraduates. This process occurred to first, identify the institutions that offered entrepreneurship initiatives for engineering undergraduate students, and second, to collect the available secondary data on these initiatives. In this research context, entrepreneurship initiatives for engineering students were the activities developed by tertiary-level academic institutions to educate their engineering students about entrepreneurship. These initiatives refer to formally arranged activities including for-credit entrepreneurship programs, entrepreneurship courses, associated co-curricular activities such as the development of new venture ideas and business plans, and optional extra-curricular activities such as new product competitions, new venture development, business plan competitions, and entrepreneurship clubs and societies.

The secondary data was collected from the webpages of these institutions. Webpages and internet data are useful sources of secondary research because they hold vast amount of data that are readily available thereby eliminating the need for other sources, and they facilitate the collection of secondary data (Mohapatra et al. 2014). In addition, the maintainers of the webpages update the data regularly resulting in the most up-to-date data being easily accessed (Mohapatra et al. 2014). To obtain this data, the webpages of the engineering school were first visited, where a search for different educational options was conducted, including entrepreneurial engineering bachelor degrees, specialised entrepreneurial minors or certificate programmes, engineering degrees combined with entrepreneurship degrees, engineering degrees combined with business or management degrees which included individual courses in entrepreneurship or entrepreneurship-related areas, and single engineering degrees with inclusive entrepreneurship or entrepreneurship-related courses.

Second, the webpages of other schools at the institution were visited. This search began with visiting the webpages of the business school, where traditionally, entrepreneurship education was offered. The aim was to identify entrepreneurship educational offerings for engineering students. These offerings included double degrees that combined engineering and entrepreneurship, or engineering and business with individual courses in entrepreneurship or entrepreneurship-related areas, minors or certificate programmes in entrepreneurship; and minors or certificate programmes in business or management with included courses in entrepreneurship or entrepreneurship-related areas. Then, the webpages of other schools at the institution were visited to identify evidence of entrepreneurship programmes, courses, and activities for engineering students. Where applicable, the webpages of any entrepreneurship schools or centres located at the academic institution were visited to search for available programs, courses, and any other activity where engineering undergraduates were able to acquire entrepreneurial knowledge and skills through their participation.

Finally, if no entrepreneurship initiatives were identified during the two previous searches, specific words and phrases were typed into the webpage's search engines to see what results were generated. The terms used included "*entrepreneurship*", "*entrepreneurial engineering*", "*entrepreneurship minor*", "*entrepreneurship program*", "*engineering entrepreneurship*", and "*engineering + entrepreneurship*". If no results were generated during the search, the institution was categorised as not offering entrepreneurship initiatives to engineering undergraduates. Once each of the 414 institutions were examined, a final list of institutions was created and then separated into two categories: those offering entrepreneurship initiatives to engineering undergraduates and those not offering entrepreneurship initiatives to engineering undergraduates. To determine the final sample for Phase One, a Microsoft Excel spread sheet was created with two columns – the name of the institutions where inserted into the first column, while the second column was used to indicate whether an institution offered entrepreneurship initiatives to engineering undergraduates. In this column, a 'Y' for Yes was placed next to the institutions that offered entrepreneurship initiatives, while an 'N' for No was placed next to the institutions that did not offer entrepreneurship initiatives. The search for entrepreneurship initiatives within these 414 institutions revealed that approximately 49% educated their engineering undergraduates about entrepreneurship. As a result, the population associated with Phase One consisted of 203 tertiary-level academic institutions in the United States. A list of the institutions included in the Phase One sample can be seen in Appendix One. During the search, details about each initiative identified were also collected and copied into individual Microsoft Word documents. These were then subjected to content analysis in order to acquire information which can be used to describe the models used by tertiary-level academic institutions to educate engineering undergraduates about entrepreneurship. Further details about the analysis process are provided in section 4.5.2

4.5.2: The Phase One Data Analysis Process

In Phase One, a manual content analysis was performed. The manual form of the content analysis is typically done using word-processing and spread sheet programmes (Tracy 2012). For Phase One, the content analysis was undertaken using Microsoft Word and Microsoft Excel. The content analysis performed was adapted from the eight steps outlined by Creswell (2014). In the first and second steps of the Creswell (2014) process, it was first important to gain a sense of the whole document and make note of any relevant ideas, and then to analyse the documents for specific details that allow for any specific themes and overall meanings to be identified. The content of the Microsoft Word documents used in this research represented the entrepreneurship initiatives for engineering undergraduates offered by the academic institutions in the sample. When the data was copied from the institutions' webpages, it was organised into relevant headings which facilitated the ease of the document analysis. Notes were also made in the documents regarding any specific areas of importance that were relevant to the research topic.

In the third and fourth steps of the Creswell (2014) process, it was important to ensure that the analysis process be done for several of the researcher's documents, where topics were identified, the data organised according to the specific topics, and the topics arranged into major topics, sub topics, and remaining information; and then to ensure the categories were applied to the text in the remaining documents so that both text and categories were appropriately matched. For this research, the components of the models from the original

Standish-Kuon and Rice (2002) typology were first identified in the information collected from each institution. These components included:

- the schools responsible for the creation of the entrepreneurship initiatives;
- the location of the entrepreneurship initiatives;
- the target students of the entrepreneurship initiatives;
- the type of curriculum used in the entrepreneurship initiatives;
- the faculty responsible for teaching in the entrepreneurship initiatives; and
- the schools within which the faculty were located.

The data was then classified according to these categories. Any information relating to the respective categories that deviated from the characteristics outlined in the Standish-Kuon and Rice (2002) typology was noted and stored for the model descriptions. The remaining data was classified into other categories that were frequently identified throughout the documents, which then aided in the description of the models.

The fifth step of the Creswell (2014) process involved the transformation of descriptive words and themes from the topic under analysis into suitable categories. This step further involves the checking of categories to ensure that topics that relate to each other are merged into one. In this research study, the data that was acquired from each entrepreneurship initiative identified in the institutions' webpages, was compiled and organised into the following categories:

- Creation of the entrepreneurship initiative;
- The location of the entrepreneurship initiative;
- The type of curriculum used in the entrepreneurship initiative;
- The target students;
- The type of entrepreneurship initiative offered to engineering undergraduates;
- The type of educational method used;
- The location of the educational method and entrepreneurship faculty; and
- The type of practical experience offered and the location of this practical experience.

To determine how the entrepreneurship initiative was created, the description of the entrepreneurship initiative from the institutions' webpages was explored to identify the origin of the initiative. This involved discovering which of the institutions' schools were responsible for the existence of the initiatives. Information about where these initiatives were located was also collected. For example, initiatives were identified that had been created by both the business and engineering schools, however, the initiatives were housed specifically in the engineering school for engineering undergraduates. The information about the curriculum used in the entrepreneurship initiatives was obtained from details of the content and focus of the programmes. For example, if the focus of the programme was on the development of new technologies and patents, the curriculum was identified as being technologically-focused, whereas if the focus was on the creation and development of a new business venture, the curriculum was identified as being business-focused. The information about the target students was obtained from details from the initiative descriptions pertaining to the types of students that the entrepreneurship initiative was designed for. For example, details were obtained about whether the initiative was only for engineering students, for engineering and business students only, or for all non-business students. Next, information on the entrepreneurship initiatives that were being offered, and the educational methods used, which pertained to what the initiative consisted of, was gathered from the initiative description. For example, was a bachelor degree programme offered in the entrepreneurship initiative, or did it consist of a number of individual entrepreneurship courses. The location of the educational method and the entrepreneurship faculty required details about the school or schools within which the courses were taught, and the schools within which the teaching faculty were situated. For example, details were acquired about whether the courses offered were situated in the business school despite the initiative being developed by the engineering school. Finally, details were required about the practical experiences in entrepreneurship that allowed students to put their entrepreneurship knowledge into practice. The entrepreneurship initiative descriptions were first examined to determine whether or not the students received hands-on experiences in entrepreneurship. Then, the sections of initiative descriptions pertaining to practical experiences were further examined to determine the types of practical experiences offered and the schools within which the practical experiences were offered.

In the sixth step of the Creswell (2014) process, codes had to be created that represented each of the categories developed, and these codes had to be alphabetised. This step was not necessary for the manual analytical process conducted in Phase One, due to the categories being necessary for the categorisation of the data and the description of the models, not the codes. For all of initiatives identified in the institutions included in the sample, information was documented in a Microsoft Excel spread sheet. The details of each single initiative were entered within an individual row, divided into different columns. In this spread sheet, the columns were populated with the following:

- The name of the tertiary-level academic institution;
- The U.S. state that the institution was located in;
- The name of the entrepreneurship initiative;
- The institution school responsible for the creation of the entrepreneurship initiative;
- The institution school within which the entrepreneurship initiative was located;
- The type of curriculum used in the entrepreneurship initiative;
- The target students of the entrepreneurship initiatives;
- The type of educational programme offered within the entrepreneurship initiative;
- The location of the educational programme;
- The location of the faculty responsible for teaching entrepreneurship;
- The types of practical experiences offered in the entrepreneurship initiative; and
- The location within which the practical experiences were offered.

For each column – with the exception of the U.S. state, the name of the entrepreneurship initiative, and the type of practical experiences – pre-determined options were added to the spread sheet for each of the columns to represent the common options identified in the initiative descriptions. In addition, a 'Notes' column was added for specific notes to be made about each of the initiatives, and a 'Web Links' column was added for links to the initiative descriptions on the institution webpages to be inserted for future reference. 'Other' columns were also added throughout the Microsoft Excel spread sheet for each of the areas listed above (with the exception of the U.S. state, the name of the entrepreneurship initiative, and the types of practical experiences), which allowed for data entry of options that were outside the norm and helped to highlight any exceptions that existed in the initiatives. Finally, a 'Model' column was included to indicate which model the initiative followed, which was determined in the final steps of the content analysis process.

The final two steps of the Creswell (2014) process involved combining all the data belonging to each category into one place to perform a preliminary analysis, and then finally re-coding any existing data where necessary. In this study, the final steps of the content analysis involved the categorisation of the entrepreneurship initiatives according to the distinguishing criteria identified in the Standish-Kuon and Rice (2002) typology was used – i.e. the schools that were responsible for the creation of the entrepreneurship initiatives and the schools which housed the entrepreneurship initiatives. As determined in the Standish-Kuon and Rice (2002) study, three models were used by institutions to educate engineering students about entrepreneurship: the *Business School* model, the *Engineering School* model, and the *Multi-School* model. Initiatives created by, developed by, or emanating from the business school were categorised as *Business School* model initiatives. Initiatives developed by the engineering school with initiatives housed primarily housed within the engineering school were categorised as *Engineering School* model initiatives. Initiatives developed as a result of collaboration among the engineering school, the business school, and some (but not all) of the other schools at the institution were categorised as *Multi-School* model initiatives.

Entrepreneurship initiatives that did not meet the original criteria identified in the Standish-Kuon and Rice (2002) study – i.e. initiatives that did not originate from the business school, the engineering school, or collaboration between the engineering, business, and other schools – were then placed into a separate group. This group was then examined according to the schools responsible for the creation of the initiatives and the schools within which the initiatives were housed. This resulted in the division of this group into two distinct groups. The newly identified distinguishing criteria laid the foundation for the creation of two new models that represented the initiatives that did not meet the original criteria of the Standish-Kuon and Rice (2002) models. Where institutions had multiple initiatives, each initiative was independently evaluated to determine whether or not they followed the same models. When an institution had multiple initiatives originating from the same source, for example where each initiative for engineering undergraduates was developed solely by the engineering school, the institution was categorised as following a single model. Alternatively, when an institution had multiple initiatives originating from different sources, for example where one initiative was developed solely by the engineering school and another was developed by the academic institution, the institution was categorised as following more than one model.

The addition of these two new models to the original three models formed the basis for a new typology. Before progressing to Phase Two, the credibility of the new typology was evaluated using Hunt's (1976, 2010) criteria for acceptable classification schemata. Hunt (1976, 2010) stated that an accepted typology is one that will:

1. adequately specify the phenomenon to be classified;
2. adequately specify the properties or characteristics that will be doing the classifying;
3. have mutually exclusive categories;
4. have collectively exhaustive categories; and
5. be useful.

In the first criterion, the question is whether the 'what' which is being categorised has been identified (Hunt 1976, 2010). In the case of the second criterion, the question is whether the properties or characteristics used in the classification are appropriate and used consistently throughout the classification process (Hunt 1976, 2010). For the third criterion, the question is whether the item under investigation could fit into one category but no other Hunt (1976, 2010). The question in the fourth criterion referred to whether the item under investigation had a "home" or a category to belong to Hunt (1976, 2010). In the fifth criterion, the final question asked was whether the typology overall was useful and had therefore achieved its purpose Hunt (1976, 2010). In structuring the typology, these criteria were used in the categorisation of the initiatives as a way of testing the typology and its applicability. The assessment of the new typology and its suitability for the categorisation of entrepreneurship initiatives for engineering students is discussed in Chapter 7.

Following the identification and the categorisation of the initiatives according to the models followed, the 'Model' column of the Microsoft Excel spread sheet was completed with the name of the model that each initiative followed. Additional spread sheets were then created, with details of the entrepreneurship initiatives for each model being combined to provide a descriptive summary of each model and facilitate the descriptive component of Phase One. The spread sheets therefore contained the information needed to describe the models used by tertiary-level academic institutions in the United States. Given that the United States pioneered the entrepreneurial engineering movement, the typology of models identified in Phase One was used as the framework to investigate the models used outside the United States.

4.6: The Research Study: Phase Two

In Phase Two, the objective was to identify the models used by tertiary-level academic institutions outside the United States to educate engineering undergraduates about entrepreneurship. Phase Two replicated the methods used in Phase One in order to examine the entrepreneurship initiatives for engineering undergraduates offered by tertiary-level academic institutions in Australia, Canada, New Zealand, and the United Kingdom. This section provides information about the sample, data collection process, and data analysis process used Phase Two.

4.6.1: The Phase Two Sample and Data Collection Process

As in Phase One, the determination of the Phase Two sample and the data collection process occurred simultaneously. To select the relevant sample for Phase Two, it was first necessary to identify the population and the sample frame. The population of Phase Two was the same as that of Phase One – tertiary-level academic institutions in the relevant countries that offered entrepreneurship education to engineering students. However, in Phase Two, the focus was on identifying the models used by academic institutions in Australia, Canada, New Zealand, and the United Kingdom to educate engineering undergraduates about entrepreneurship. As a result, Phase Two's sample frame consisted of academic institutions in the four countries that offered entrepreneurship education to engineering students at various tertiary levels.

Purposive sampling was used to identify the institutions included in the Phase Two sample. As in Phase One, the sample was selected from institutions with undergraduate engineering programmes accredited by the main engineering accreditation boards in each country: *Engineers Australia* in Australia, *Engineers Canada* in Canada, *Institution of Professional*

Engineers New Zealand (IPENZ) in New Zealand, and *Engineering Council U.K.* in the United Kingdom. These programmes were selected because a review of the accreditation criteria revealed a requirement for technical and non-technical skills similar to those reflected in ABET's Criterion 3. The list of institutions was acquired and compiled from member lists downloaded from the webpages of the four accreditation boards. For inclusion in the sample, institutions had to have undergraduate engineering programmes accredited by the relevant accreditation boards and offer entrepreneurship education to engineering undergraduates.

To develop the sample, the webpages of the institutions in Australia, Canada, New Zealand, and the United Kingdom that offered entrepreneurship education to engineering students at various tertiary levels, were examined. As presented in Figure 2, Phase Two required the collection of data about entrepreneurship initiatives for engineering undergraduates offered at academic institutions in the four countries. As in Phase One, the webpages of these institutions were reviewed for evidence of entrepreneurship programmes, courses, and activities that were offered to engineering undergraduates in order to acquire all information from the entrepreneurship initiatives. First, the webpages of the engineering school were visited to determine if entrepreneurship initiatives designed for undergraduates were present, and if they were, to identify the educational options that the initiatives offered. This included a search for options including entrepreneurial engineering bachelor degrees, specialised entrepreneurial minors or certificate programmes, engineering degrees combined with entrepreneurship degrees, engineering degrees combined with business or management degrees with individual courses in entrepreneurship or entrepreneurship-related areas, and single engineering degrees with entrepreneurship or entrepreneurship-related content and courses. Details of each option identified were placed in Microsoft Word documents, with one document created for each institution.

Next the webpages of other schools within each sample institution were visited – including the business school, other non-business schools, and where applicable, entrepreneurship schools and centres – to determine if there were available programs, courses, or activities that engineering undergraduates were able to participate in to acquire entrepreneurial knowledge and skills. These offerings included double degrees that combined engineering and entrepreneurship or engineering and business with individual courses in entrepreneurship or entrepreneurship-related areas, minors or certificate programmes in entrepreneurship, and minors or certificate programmes in business or management with included courses in entrepreneurship or entrepreneurship-related areas. Microsoft Word documents were used to combine information of the initiatives for each of the academic institutions.

Finally, if entrepreneurship initiatives for engineering undergraduates were not easily identified on the webpages of the individual schools, a general search was conducted, with relevant words and phrases typed into the institution's online search engines. These words and phrases included "*entrepreneurship*", "*entrepreneurial engineering*", "*entrepreneurship minor*", "*entrepreneurship program*", "*engineering entrepreneurship*", and "*engineering + entrepreneurship*". If any relevant results were generated, the institution was identified as offering entrepreneurship education to engineering undergraduates. However, if no results were generated from the searches, the institution was classified as not having entrepreneurship initiatives for engineering undergraduates.

On completion of the desktop searches, the institutions for each country were separated into two groups: those offering entrepreneurship initiatives to engineering undergraduates and those not offering entrepreneurship initiatives to engineering undergraduates. Like Phase One, a Microsoft Excel spread sheet with two columns was created for each of the four countries, with the names of the institutions inserted into the first column, and information about whether or not an institution offered entrepreneurship initiatives to engineering undergraduates inserted into the second column. In the second column, a 'Y' was placed next to the institutions that offered entrepreneurship initiatives to engineering undergraduates to represent Yes, while an 'N' was placed next to the institutions that did not offer entrepreneurship initiatives to engineering undergraduates to represent No. This process, which was conducted in May 2015, revealed a sample frame consisting of a total of 186 institutions: 36 in Australia, 42 in Canada, eight in New Zealand, and 100 in the United Kingdom. The sample obtained represented 42% of the sampling frame, with a final total of 78 institutions. This sample included 13 institutions in Australia, 24 institutions in Canada, five institutions in New Zealand, and 36 institutions in the United Kingdom. A list of the institutions included in the Phase Two sample can be seen in Appendix Two.

Following the searches, a content analysis was undertaken to categorise the initiatives identified in each of the four countries according to the relevant models, and therefore to develop a descriptive summary of each model. For the analysis to be conducted, the data was prepared by placing all information pertaining to the entrepreneurship initiatives in Microsoft Word documents. This resulted in the creation of 78 Microsoft Word documents, each containing details of the initiatives at each institution included in the sample. The analysis process conducted in Phase Two is further discussed in section 4.6.2.

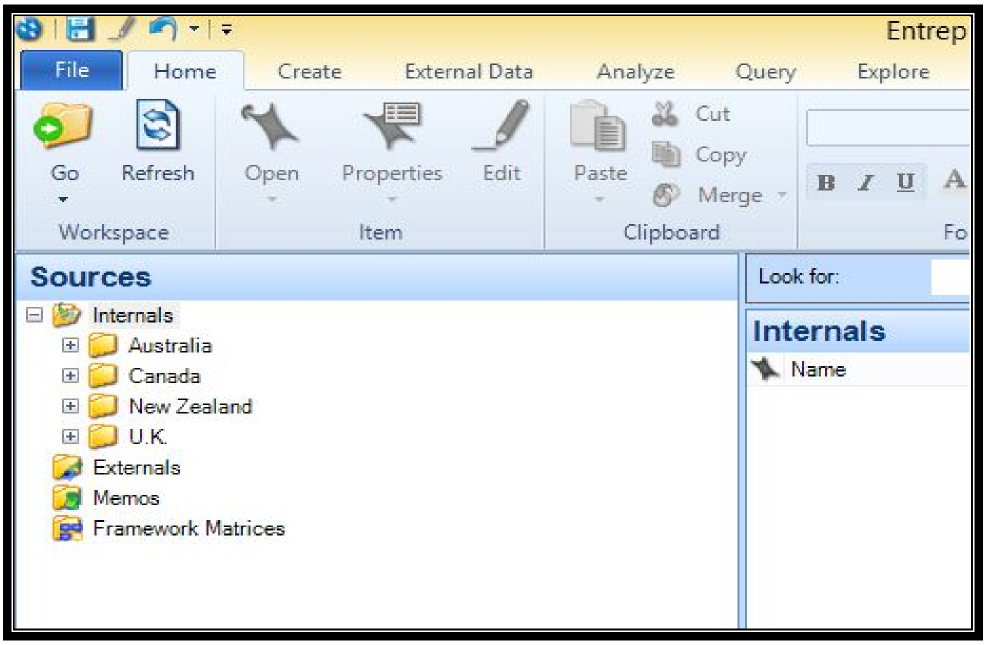
4.6.2: The Phase Two Data Analysis Process

In contrast to the manual content analysis performed during Phase One, in Phase Two, a computerised content analysis was conducted using Computer-aided qualitative data analysis software (CAQDAS). CAQDAS is software used specifically for qualitative data analysis that facilitates the sorting, management, coding, organisation and interpretation of data, but does not conduct the analysis on its own (Tracy 2012). Using CAQDAS has several benefits. For this research, the use of CAQDAS allowed for the ability to interact with the data – for example, to search for the relevant data, organise the data, code the data, and also retrieve any specific data required (Tracy 2012). In addition, CAQDAS allows for the creation of memos and notes which are based on the data analysis which could also be coded during the process (Tracy 2012). CAQDAS was used in Phase Two to compare the use of manual and computer processes, and investigate whether there was a more efficient method for evaluating the details of entrepreneurship to categorise initiatives according to respective models. Despite the recognised disadvantages associated with CAQDAS – for example, the cost and the availability of the software (Tracy 2012) – its use helped for a clear picture of the research topic to be seen.

The CAQDAS programme selected for this research project was N-Vivo, in the case of this study, N-Vivo Version 10. Research has shown that N-Vivo is one of the three most popularly used CAQDAS programmes (Gibbs 2007; Saldaña 2009). In addition, N-Vivo is the most commonly used CAQDAS offered at the University of Tasmania, the institution through which this research study was conducted. As such, N-Vivo was the most easily accessible software for the computerised content analysis, which is why it was utilised for the data analysis conducted in Phase Two.

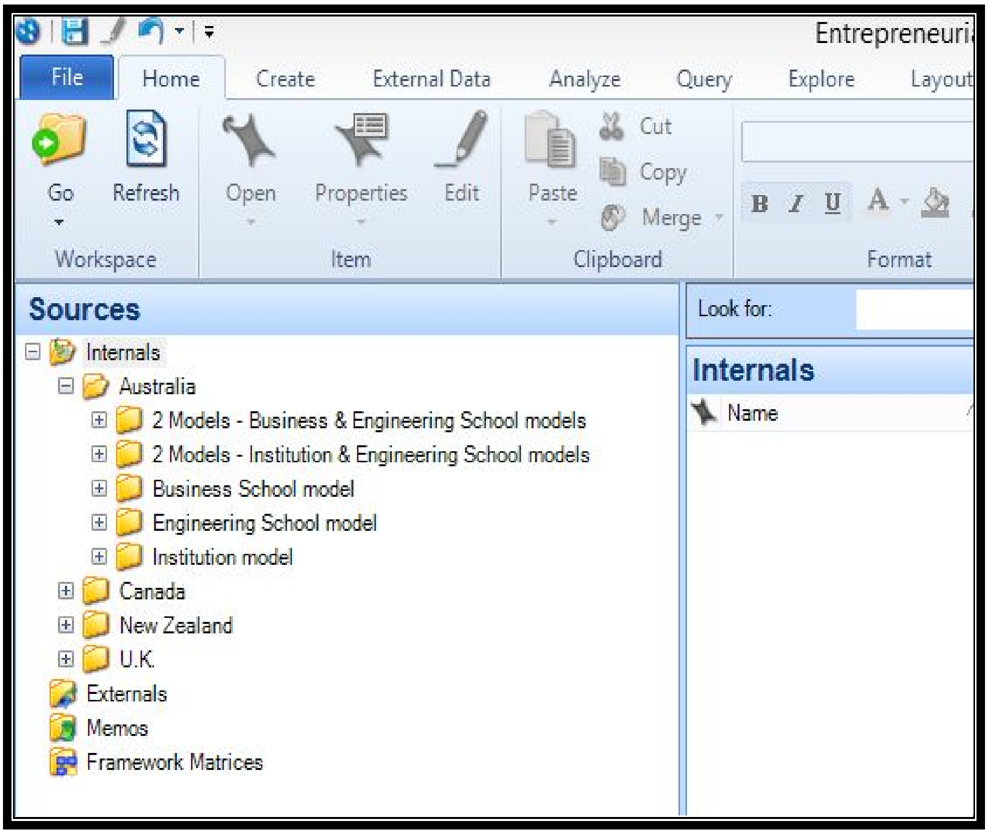
The first step of the computerised content analysis process in N-Vivo involved setting up and creating a new project using the Microsoft Word documents created for each of the sample's institutions. Before the computerised analysis was performed, the distinguishing criteria of the models identified in Phase One were used to categorise the entrepreneurship initiatives and their respective institutions according to the pre-determined models – i.e. the schools that were responsible for the development of the entrepreneurship initiatives and the location of the entrepreneurship initiatives. First, a folder for each country – i.e. Australia, Canada, New Zealand, and the United Kingdom – was created in N-Vivo, as shown in Figure 3.

Figure 3: The folders created in N-Vivo for *Source* documents



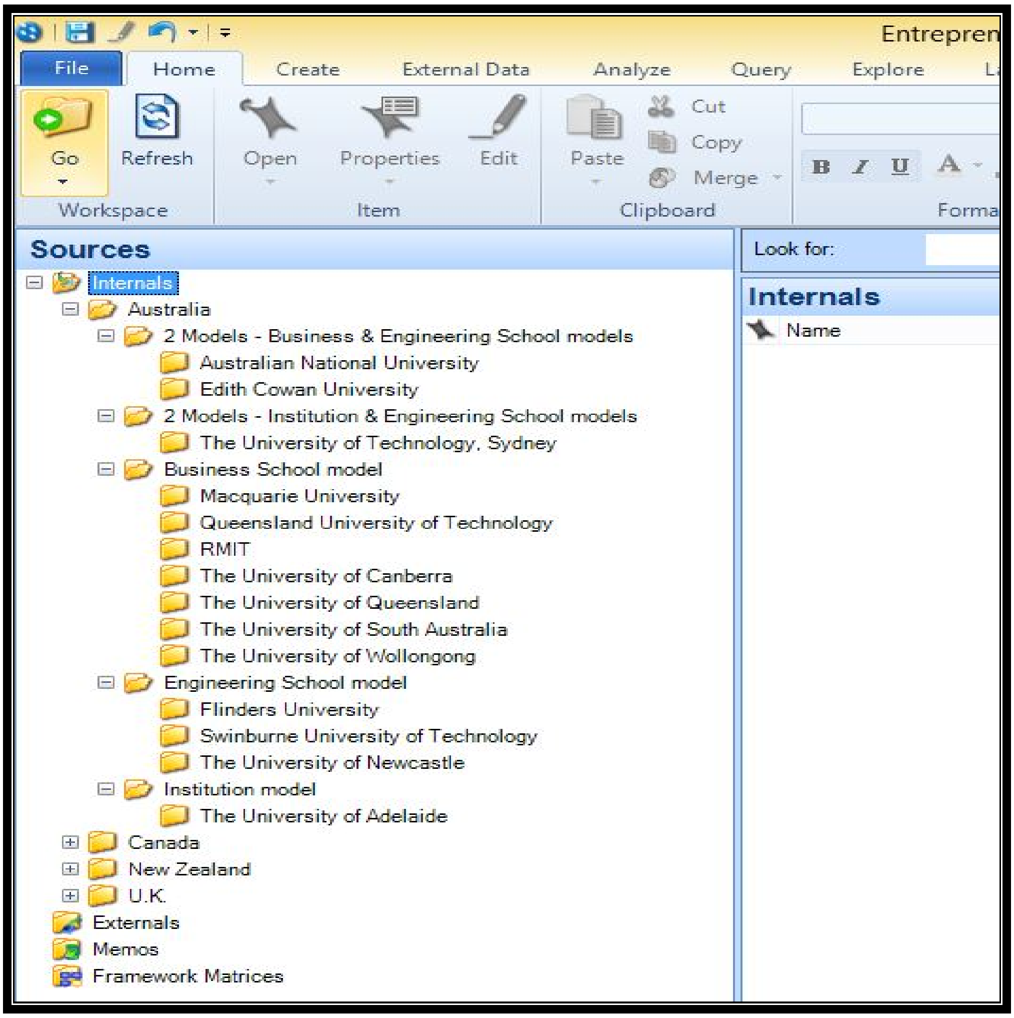
To create the folders, it was necessary to right-click on 'Internals', select 'New Folder', and then give the folder the appropriate name (Silver & Lewins 2014). Four folders were created, each named after the four countries included in Phase Two. Under each folder, mid-level folders were created representing, and therefore named after, each of the pre-determined models. If instances where institutions followed multiple models, additional folders were created which were named after these models. This is shown below in Figure 4.

Figure 4: The mid-level folders created in N-Vivo for *Source* documents



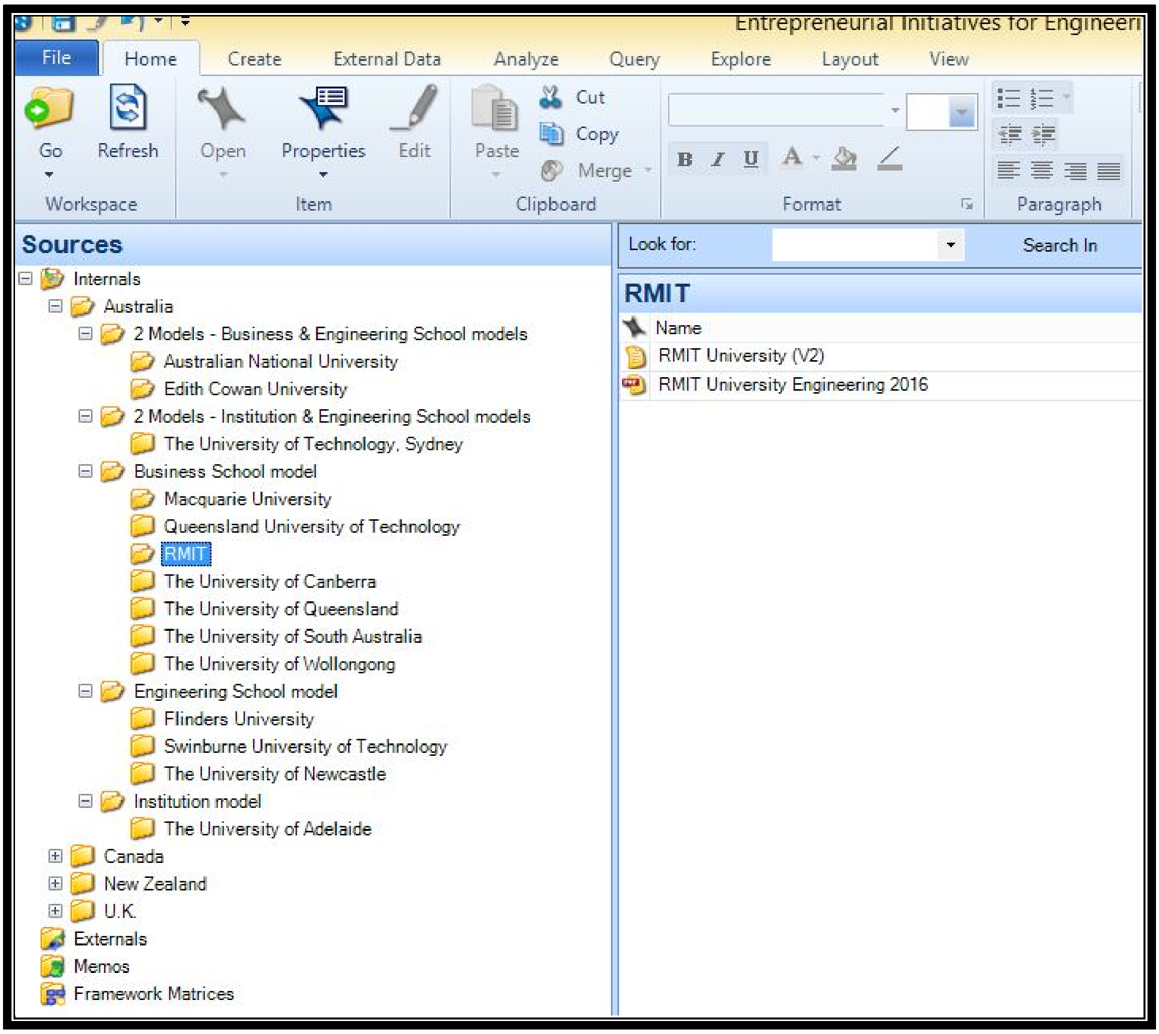
Under each mid-level folder, additional sub-folders were created, named after the institutions with initiatives that followed the respective model or models, as shown in Figure 5.

Figure 5: The third level folders created in N-Vivo for *Source* documents



The second step of the computerised content analysis was to import *Source* documents for analysis. *Source* documents, a term specific to the N-Vivo programme, refers to any type of data file or memo that is either embedded into the research study or exists externally from the study (Silver & Lewins 2014). These documents include, for example, textual documents, pdf documents, spread sheets, multimedia, and data sets (Silver & Lewins 2014). The *Source* documents for this research were the Microsoft Word documents created during the data collection that contained information about the entrepreneurship initiatives. The documents that were created for each of the institutions were then organised into folders according to the country and model. This is illustrated in Figure 6.

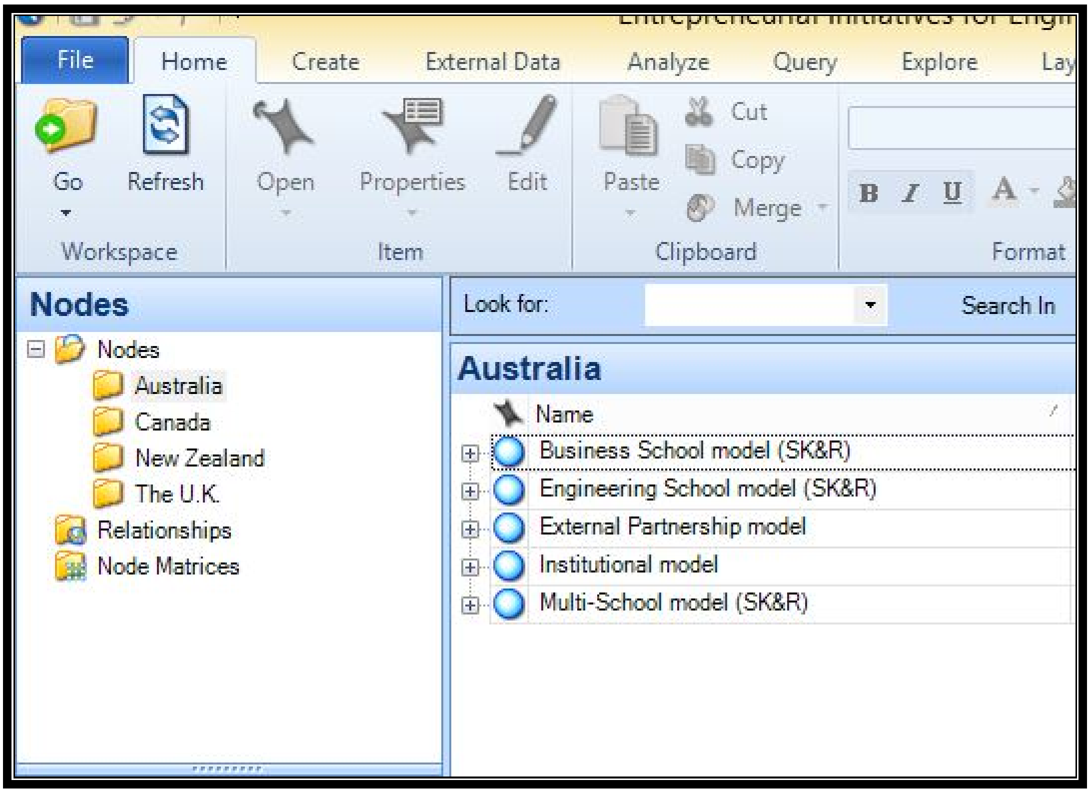
Figure 6: An example of the *Source* documents imported in N-Vivo for analysis



In addition, preliminary notes about the entrepreneurship initiatives were made in N-Vivo about the entrepreneurship initiatives to facilitate the coding of the data and prepare notes that could be double checked for consistency during the analysis process.

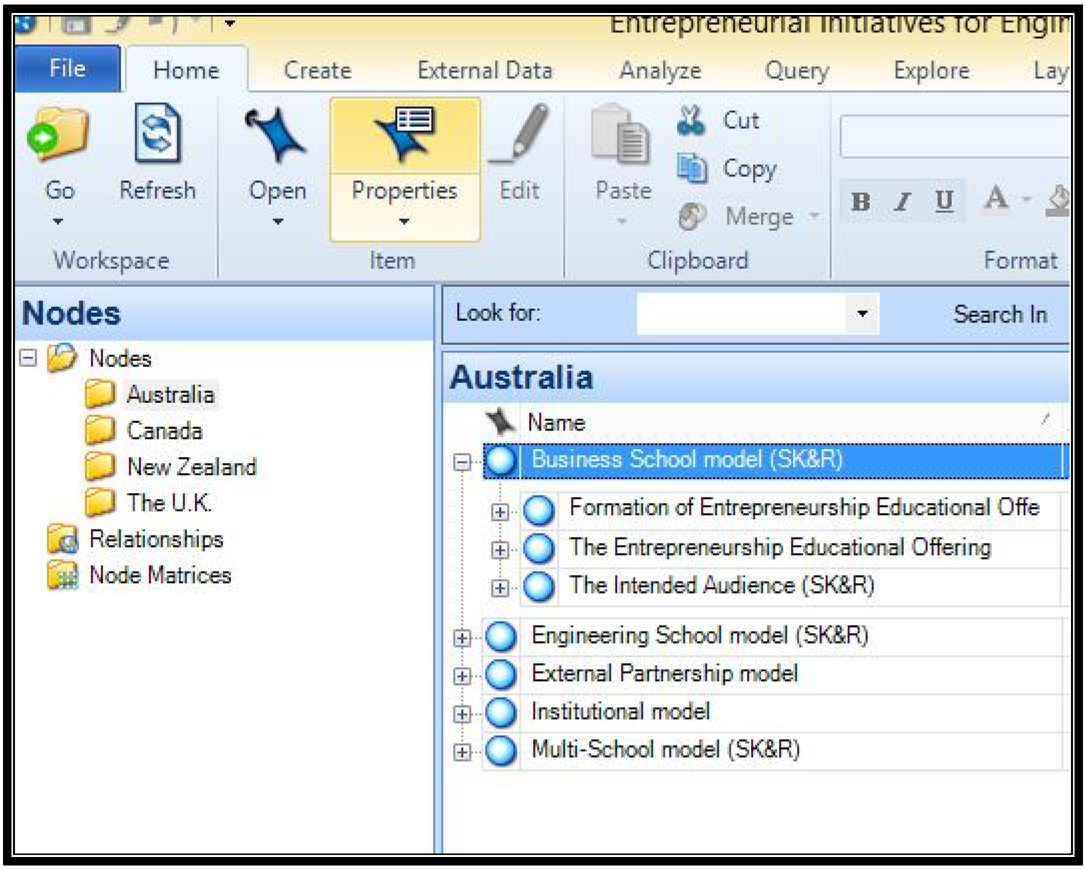
The third step of the computerised content analysis involved the creation of the *Nodes* into which the data from the *Source* documents had to be coded. A *Node*, which is an N-Vivo specific term, is a containers that houses data and facilitates data retrieval and organisation (Silver & Lewins 2014). *Nodes* can either contain data, or exist in a hierarchy with different levels of nodes that could either be empty to facilitate the hierarchy (Silver & Lewins 2014). In this research study, the *Nodes* contained specific information about the entrepreneurship initiatives. The hierarchy of *Nodes* created was in line with the typology developed in Phase One of the project. The *Nodes* in the first level of the hierarchy, referred to as *Parent Nodes*, were named after the models developed in Phase One, as shown in Figure 7.

Figure 7: The *Parent Nodes* created in N-Vivo for data coding



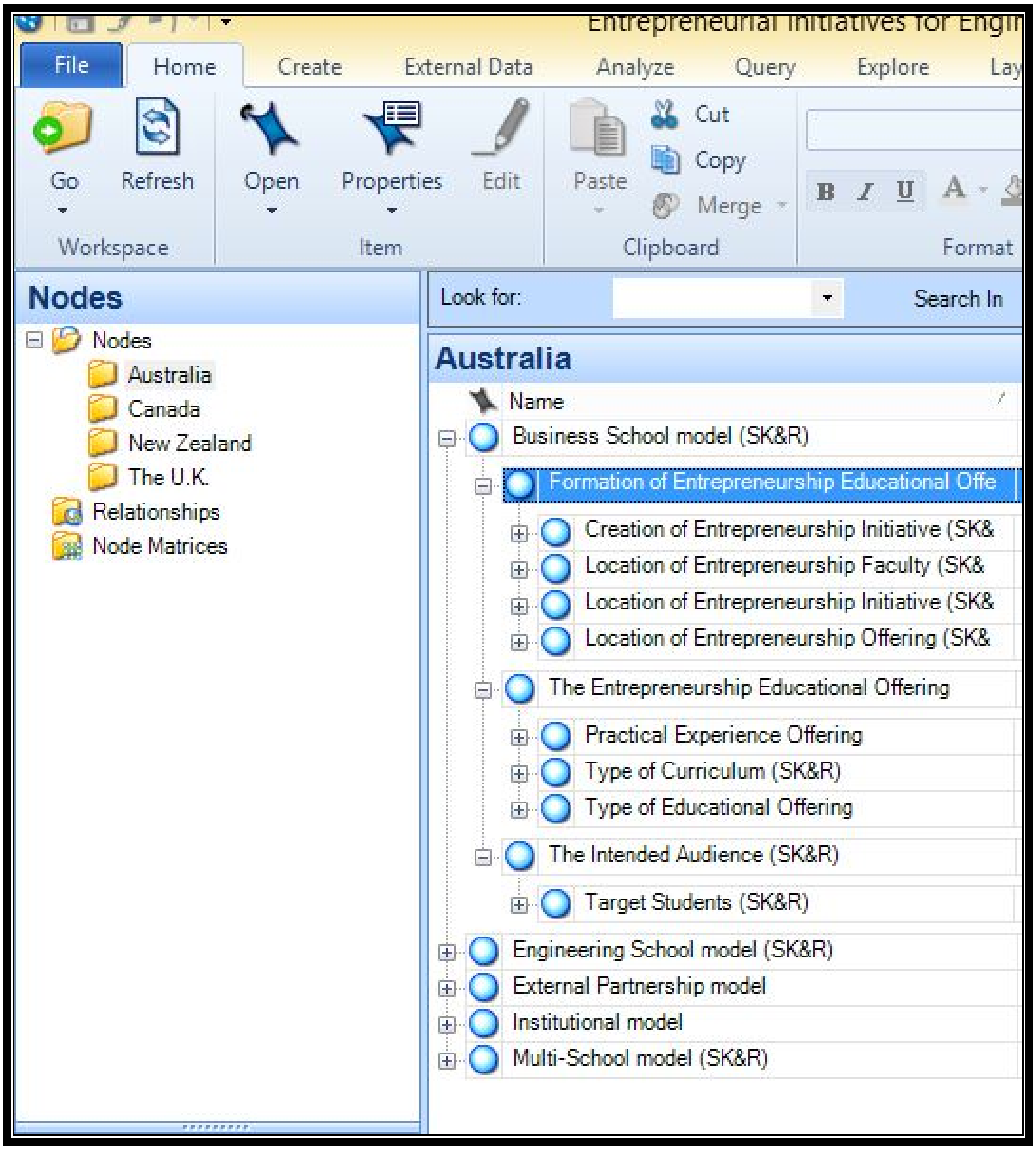
The second level of *Nodes* created, referred to as the *Child Nodes*, was named after the categories of information related to the model that were identified in Phase One. These categories resulted in the development of three *Child Nodes*: 'Formation of the Entrepreneurship Initiative', 'The Entrepreneurship Educational Offering', and 'The Intended Audience'. This is shown in Figure 8.

Figure 8: The *Child Nodes* created in N-Vivo for data coding



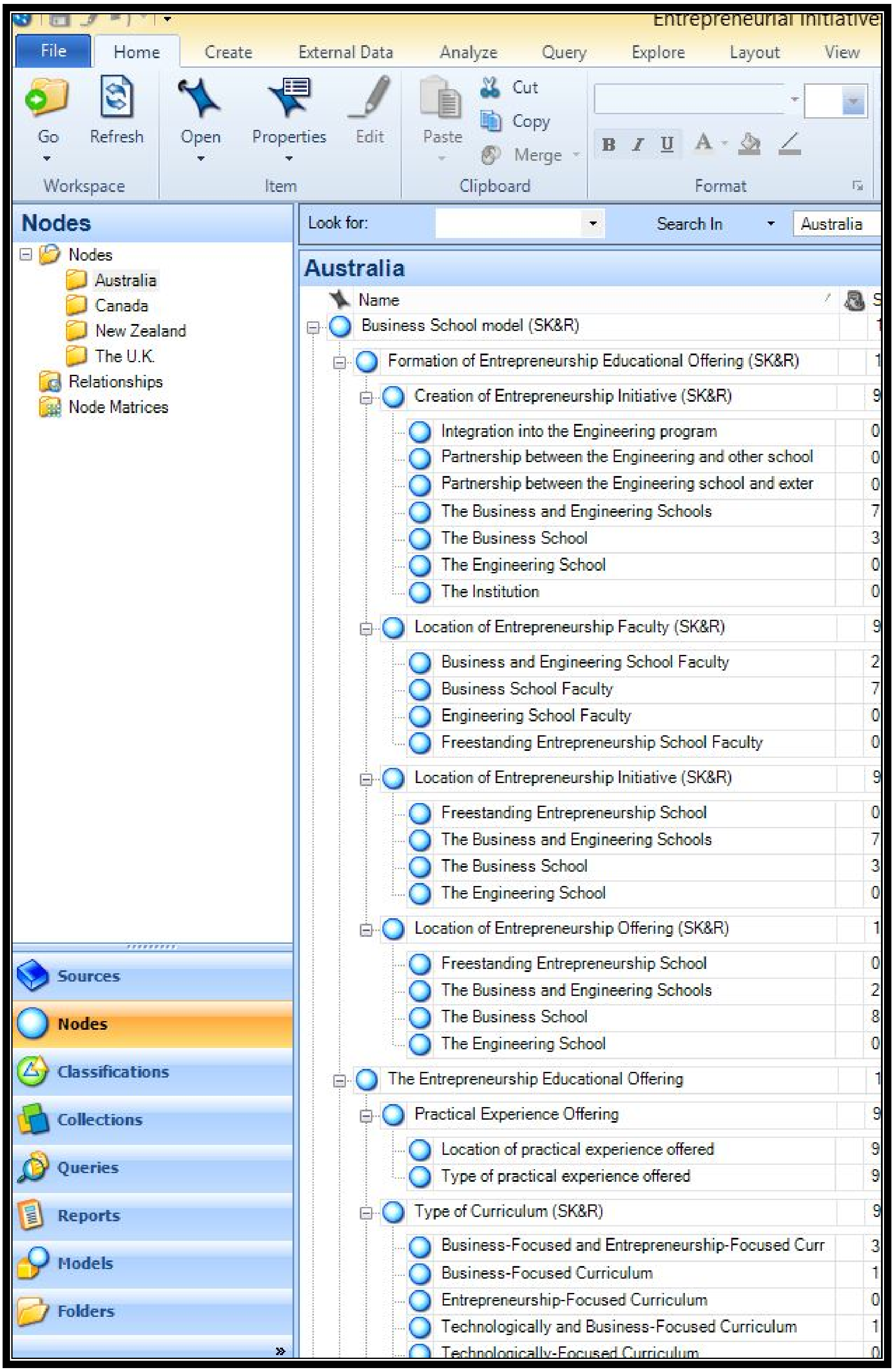
The third level of *Nodes*, referred to as *Grandchild Nodes*, showed a breakdown of the types of information present in the three *Child Nodes*, as illustrated in Figure 9.

Figure 9: The *Grandchild Nodes* created in N-Vivo for data coding



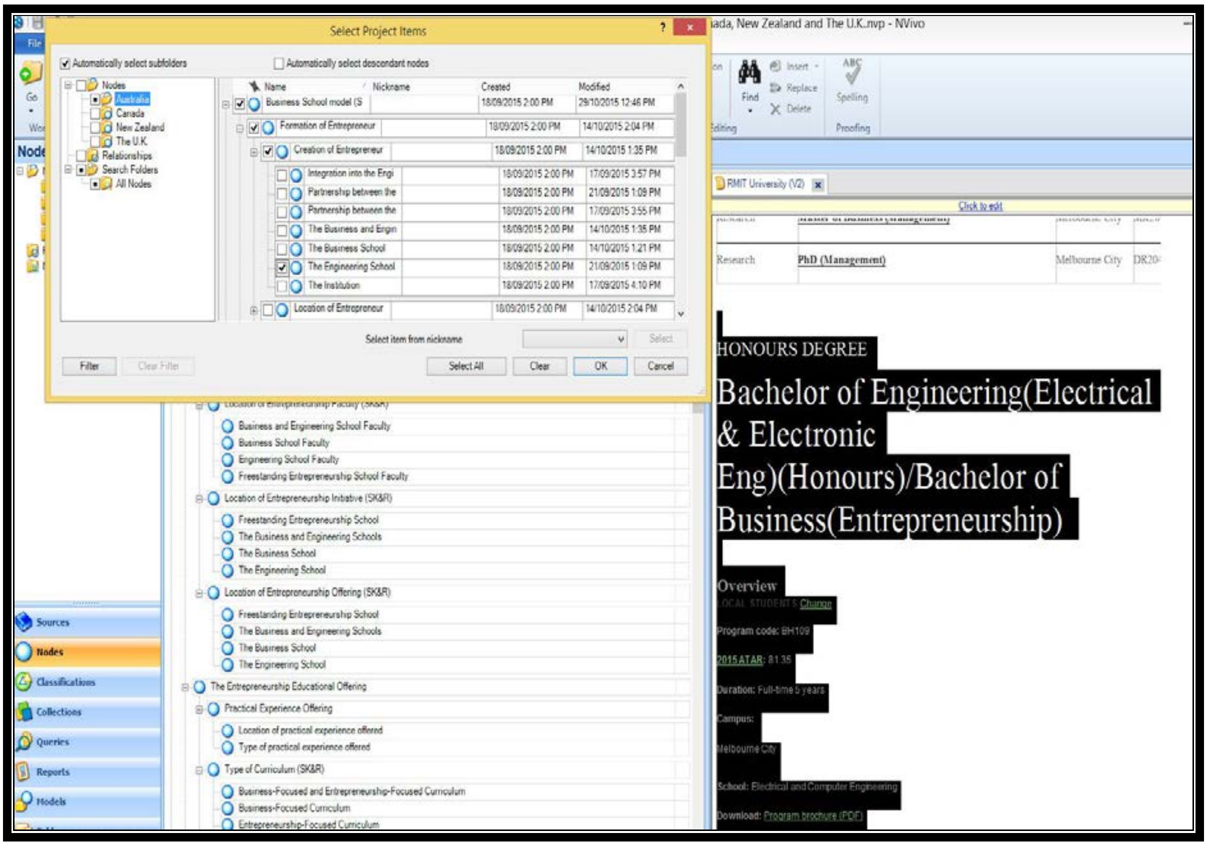
The fourth, and final, level of *Nodes*, referred to as *Great-Grandchild Nodes*, represented the different types of information that were identified in the entrepreneurship initiative descriptions. These *Nodes* were named after the types of information acquired in Phase One, with *Nodes* subsequently added based on additional information identified in the initiative descriptions. The final hierarchy of *Nodes* is illustrated in Figure 10.

Figure 10: The *Great-Grandchild Nodes* created in N-Vivo for data coding



Once the new project was set up in N-Vivo, the next step was to code the data, which firstly required the development of a list of *Coding Rules* for the different *Nodes*, which outlined the type of data that needed to be coded into each *Node*. *Coding Rules* were used as a guideline to ensure that the data coded to a particular Node was relevant and coded correctly. The list of *Coding Rules* used in this research project can be found in Appendix Three. The coding of the data to the relevant *Nodes* was organised by institution. The *Source* document belonging to each institution was opened and all useful data were coded to all the relevant *Nodes*. If useful data were identified but did not have a *Node* to be coded into, new *Nodes* were created. To code the data to the *Nodes*, the relevant text was first highlighted, then a right-click action was performed; from the list that appeared, 'Code Selection' was selected followed either by 'Code Selection at Existing Nodes' or 'Code Selection at New Node', depending on whether the *Node* was a new *node* that had to be created or one that was already created, and this populated the *Node* (Silver & Lewins 2014). An example of this process is presented in Figure 11.

Figure 11: Illustration of the N-Vivo coding process



To facilitate the coding process, the decision was made to code data obtained from all institutions within a particular country before moving on to the coding of the data from other countries. Although the data was coded into specific *Nodes*, a broad picture of what was happening in a particular institution was developed by simultaneously coding data to each of the *Parent Nodes*. Furthermore, the coding of all data for an institution into the *Parent Node* allowed for all data regarding the entrepreneurship initiatives offered by an institution to be present in one location.

The analysis of the data in Phase Two was based on the models and information identified in Phase One. As a result, if any required information was not present in the Microsoft Word documents created for each institution in the Phase Two sample, the institution's webpages were examined to acquire the necessary data. If this data was unavailable, the information was simply excluded from the coding, and notes were made indicating that certain types of information could not be located. This coding process was conducted for each of the four countries. During the coding process, findings were documented so that the picture of each model identified in each of the four countries could evolve. This evolution continued as additional initiatives were examined.

To ensure the quality of the data and the resultant findings, each *Node* in turn was opened and the information reviewed multiple times. These checks were done to ensure that data was coded into the correct *Nodes*. If any data was coded incorrectly, it was re-coded into the correct node. Once the analysis and quality checks were completed, full descriptions of the models, and important statistics, were produced. The findings from Phase Two were then used to identify and describe the models that were being used by academic institutions outside the United States to educate engineering undergraduates about entrepreneurship. The Phase Two findings were compared to those acquired in Phase One in order to determine whether any differences existed between U.S. and non-U.S. academic institutions with regards to how engineering undergraduates are educated about entrepreneurship.

4.7: The Research Study: Phase Three

Phase Three had three main objectives: to confirm the findings from the first two phases, to acquire any additional information that could not be obtained in the first two phases, and to capture data from other institutions that may not have been identified as offering entrepreneurship to engineering undergraduates in the first two phases. This section provides information about the sample used in Phase Three, the data collection process used, and the methods used for data analysis.

4.7.1: The Phase Three Sample

The sample for Phase Three was comprised of the population totals from Phases One and Two. In Phase One, as explained in section 4.5.1, the population consisted of 414 academic institutions in the United States. The population of Phase Two consisted of 186 academic institutions, of which 36 were in Australia, 42 in Canada, 8 in New Zealand, and 100 in the United Kingdom. Therefore, the final population for Phase Three consisted of 600 tertiary-level academic institutions across Australia, Canada, New Zealand, the United Kingdom, and the United States.

To ensure the possibility of capturing data from all academic institutions, including institutions that were not identified in Phases One and Two as providers of entrepreneurial engineering education, the decision was made to invite all 600 institutions to participate in this phase of the research. As a result, the intention was to perform a census. In comparison to sampling, a census is the researching and acquiring of data from all members of a population (Adèr & Mellenbergh 1999; Bloor & Wood 2006; Given 2008; Walliman 2006). Although a census was desired, 126 of the 600 institutions elected to participate in the research, representing a 21% response rate. Of the 126 participants, 53 stated that they did not offer entrepreneurship initiatives to their engineering undergraduates, all of which were excluded from the final sample identified in Phases One and Two. Therefore, 73 participants, accounting for 58%, stated that they offered entrepreneurship initiatives to their undergraduate engineering students. This showed that the majority of the participants who chose to participate educated their engineering undergraduates about entrepreneurship.

4.7.2: The Phase Three Data Collection Process

In Phase Three, the primary data was collected through survey research, which allows for the gathering of data through pre-determined questions (Mohapatra et al. 2014). The acquisition of the data was done through self-completion online questionnaires which were answered by the participants themselves (Singh 2007). Questionnaires are instruments comprised of a series of questions that have been designed to generate the range of data needed to achieve the goals of the research study that have the potential for both qualitative and quantitative data to be collected (Wilson 2010). The advantages of online questionnaires led to this type being selected over paper-based or postal questionnaires. First, online questionnaires are cheaper to administer resulting in wider geographical coverage and greater potential participant pool (Bryman & Bell 2011). Second, online questionnaires tend to be completed with fewer unanswered questions, resulting in less missing data (Bryman & Bell 2011). Third, the response time for completed online questionnaires is much faster as the time for return postage is eliminated (Bryman & Bell 2011). Fourth, in the case of responses to open-ended questions, respondents tend to be more likely to answer these questions online resulting in more detailed replies (Bryman & Bell 2011). Finally, because data entry is automated with many web-based survey tools providing the data in various formats (e.g. Microsoft Excel spread sheets and PDF files), online surveys have better data accuracy (Bryman & Bell 2011). Despite the associated disadvantages of online questionnaires – including potentially low response rates, the limitation to participants who are online, the need for potential participants to be motivated to respond, face confidentiality and anonymity issues, and the potential for multiple responses from an individual respondent (Bryman & Bell 2011) – the advantages of using online surveys outweighed these weaknesses. Furthermore, this research was time sensitive with the time frame allotted to completing the study being limited. The use of online questionnaires addressed both the time-sensitivity and respondent issues.

The online questionnaire used was created using the online survey platform Survey Monkey (www.surveymonkey.net). The questionnaire was first administered in five different versions, with each version specifically designed for each of the five countries. The questionnaire design included the use of appropriate terminology and expressions and took into consideration the differences between the North American and British English language. A sixth version of the questionnaire was developed and translated into Canadian French, specifically for the francophone academic institutions in Canada. To gain access to a population whose language is different from the original population that the questionnaire was designed for, it is typical to use a back-translation method (Harkness & Schoua-Glusberg 1998; Sperber 2004) and this translation method was used to prepare the sixth version of the questionnaire. The back-translation method for questionnaires is a process where a questionnaire is translated into the target language using the services of one translator and then translated back into the source language using the services of another translator who does not have access to the original questionnaire, with both questionnaires in the source language being compared on completion (Harkness & Schoua-Glusberg 1998; Sperber 2004). For this research, the translation of the English version of the questionnaire into French was done by hiring the services of a translation company in Canada. The reason why a Canadian company was selected was because it was necessary to have a questionnaire which used the relevant terminology associated with the French language spoken in Canada. To ensure that the meanings of the original questionnaire were not lost during the translation process, the services of a translation company in Australia were employed to translate the French version back into English. The aim of this was to produce a questionnaire which was either identical or equivalent to the original English language questionnaire. The purpose of a second translation was therefore to check that the translations were correctly done in order to ensure that the correct data from the francophone academic institutions was collected.

The content of the questionnaire was structured to capture information in four overall areas: demographics, how entrepreneurship is combined with engineering, the structure of entrepreneurship initiatives, and content of the entrepreneurship initiatives. Table 4 shows how the questionnaire was divided and the questions applied to each of the four areas. The questionnaire administered can be seen in Appendix Three.

Table 4: The structure of the questionnaire used in the PhD research study

Topic Area of Questionnaire	Questionnaire Question Number	Content of Question
Demographics	**1**	Name of the academic institution
	2	Name of the school/faculty which houses the engineering programmes
	3	Whether entrepreneurship initiatives are offered to engineering undergraduates
	4	The engineering majors offered by the academic institution
How entrepreneurship is combined with engineering	**7**	Whether entrepreneurship initiatives are compulsory or optional
	8	Whether the academic institution is associated with entrepreneurship-based affiliates
	9	Whether entrepreneurship is "well-supported" at the academic institution
The structure of the entrepreneurship initiatives	**5**	What led to the creation of the academic institution's entrepreneurship initiatives
	6	The location of the entrepreneurship initiatives
	10	What is offered in the academic institution's entrepreneurship initiatives
	11	Name and description of the academic institution's entrepreneurship programme for engineering undergraduates
	12	Duration of the entrepreneurship programme for engineering undergraduates
	14	What engineering undergraduates experience in entrepreneurship initiatives
	15	The target students for the entrepreneurship initiatives
	18	Type of faculty teaching the courses in the entrepreneurship programme
	19	The schools in which the entrepreneurship teaching faculty are located
	21	Where entrepreneurship courses for engineering undergraduates are delivered
The content of the entrepreneurship initiatives	**13**	The objectives of the entrepreneurship programme for engineering undergraduates
	16	The learning outcomes of the entrepreneurship programme for engineering undergraduates
	17	The entrepreneurship competencies emphasised in the entrepreneurship programme for engineering undergraduates

	22	The curriculum used in the entrepreneurship programme for engineering undergraduates
	23	The schools responsible for the development of the curriculum used in the entrepreneurship programme for engineering undergraduates
	24	The entrepreneurship opportunities provided by the academic institution for engineering undergraduates
	25	The entrepreneurship co-/extra-curricular activities offered by the academic institution to engineering undergraduates
	28	What engineering undergraduates are encouraged to do upon graduation
	29	What the academic institution offers to their alumni after graduation

Before the questionnaire was administered, a list of the deans or other senior administrative officers of the engineering schools of the 600 institutions was compiled. This list was created in a Microsoft Excel spread sheet, and the columns were populated with the names of the institutions, the names of the engineering school of the institutions, the names of the deans or other senior officers, the positions held by the individuals (for example, dean or deputy dean), and the e-mail addresses of the individuals. Once the questionnaire was prepared, an invitation email was sent to the contact person at each academic institution. Following the initial email, two follow-up emails were sent as reminders to potential participants about the research. The content of the invitation email is discussed in section 4.9.

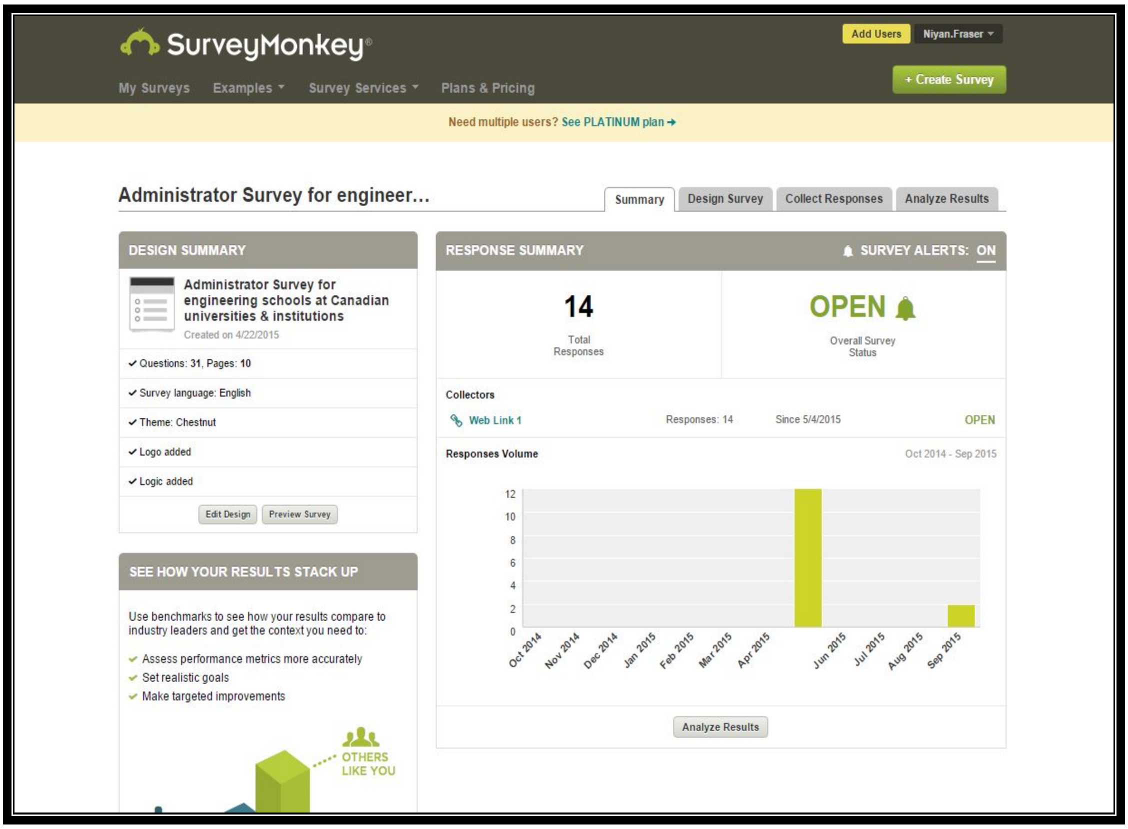
4.7.3: The Phase Three Data Analysis Process

Phase Three applied a quantitative approach to data collection. Data analysis in quantitative research involves three general stages (Tharenou et al. 2007):

1. The management of data before data entry occurs;
2. The performance of an initial data analysis to ensure the suitability of the data; and
3. The performance of a data analysis that obtains the answers to the relevant research questions and, where applicable, tests any hypotheses that were developed.

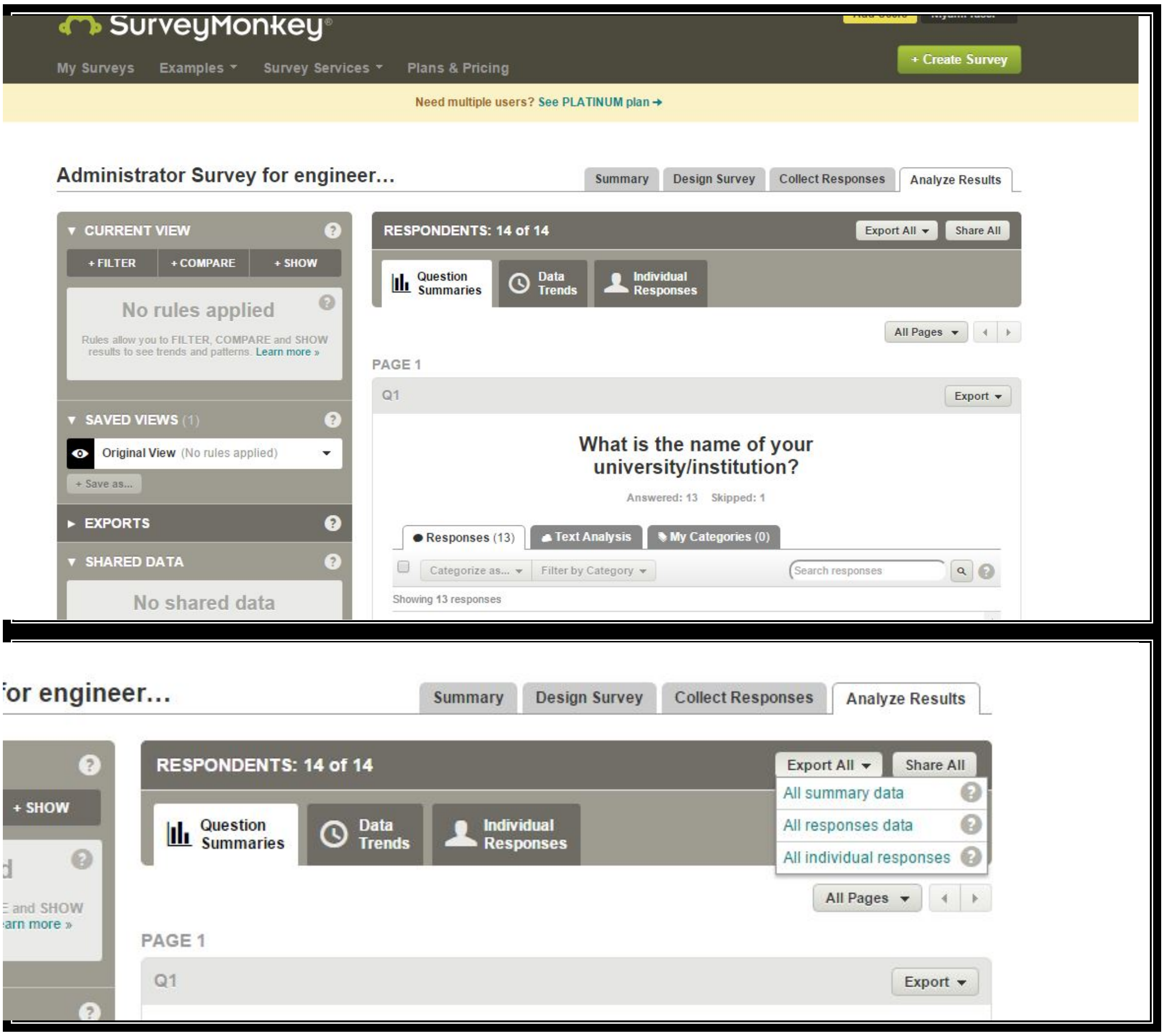
Prior to analysis, the data needed to be prepared. The data preparation involved the checking, editing, entering, and coding of the data. Since the participants in Phase Three completed their questionnaires in Survey Monkey, the first step of the data analysis process was to download the participant responses from Survey Monkey. To do this, the questionnaire was opened, as shown in Figure 12.

Figure 12: Opening the questionnaire in Survey Monkey



Once the questionnaire was opened, the data was obtained by first clicking on the 'Analyze Results' tab, then clicking on the 'Export All' tab, and selecting the 'All individual responses' option. These options in Survey Monkey are shown in Figure 13.

Figure 13: Obtaining questionnaire data in Survey Monkey

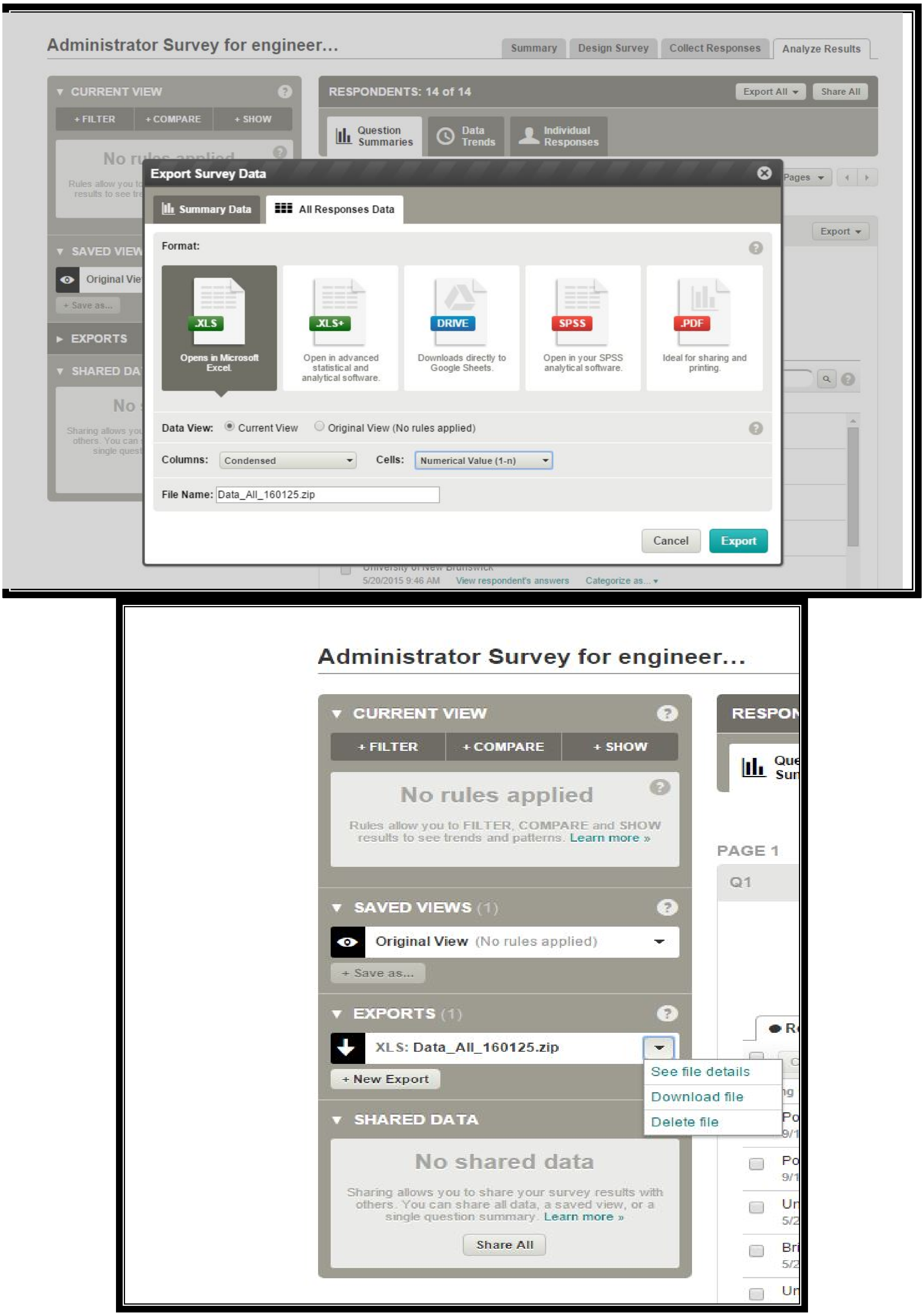


Next, the ‘All Responses Data’ tab was selected. Under this tab, the following options were selected:

- ‘Format’: Microsoft Excel;
- ‘Data View’: Current View;
- ‘Columns’: Condensed;
- ‘Cells’: Numerical Value (1-n).

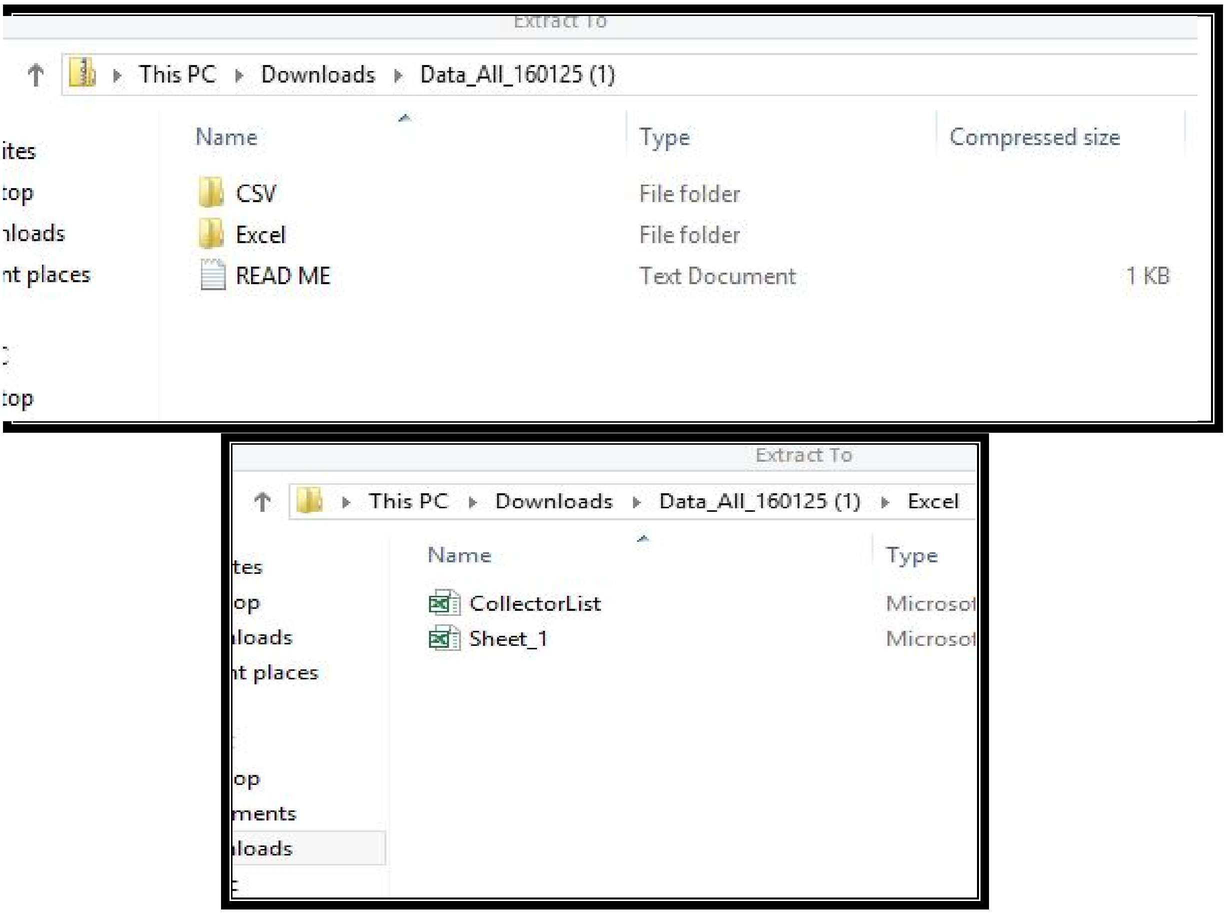
Once these options were selected, the ‘Export’ button was clicked on to produce and download the file for analysis. This is illustrated in Figure 14.

Figure 14: Obtaining the data set from Survey Monkey



The downloaded file was then prepared for analysis. The file was first opened, and then the Excel folder was opened and the Microsoft Excel spread sheet entitled ‘Sheet_1’ located in this folder was opened. This is shown in Figure 15.

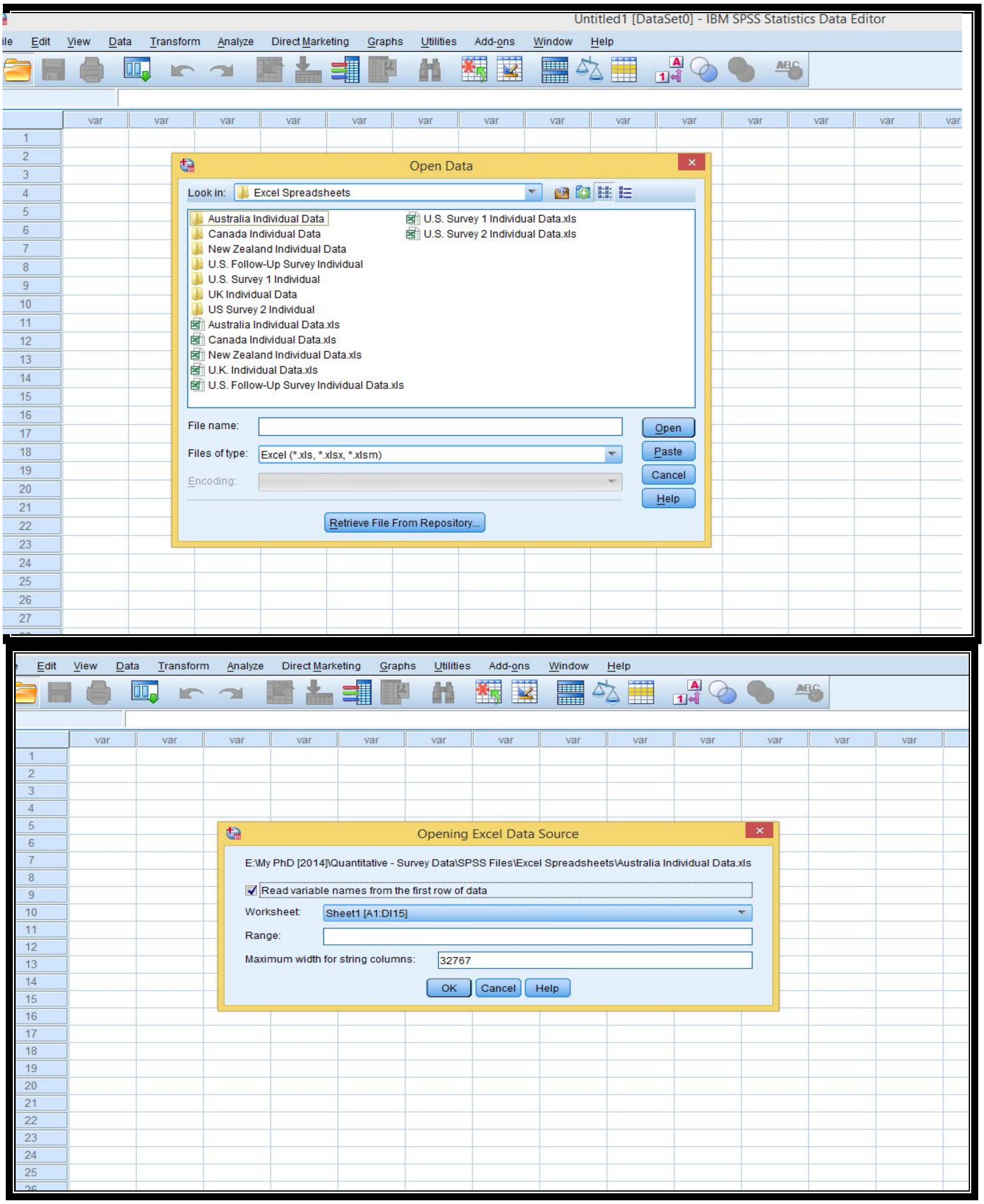
Figure 15: Opening the downloaded file from Survey Monkey



The ‘Sheet 1’ spreadsheet was examined to remove any unnecessary data and edited to present the data in the required format. As explained in section 4.7.2, 6 versions of the questionnaire were created on Survey Monkey leading to the download of 6 files, with each file representing the total responses attained from each of the questionnaires administered. The 6 files were merged into one Microsoft Excel file for analytical purposes, with the data edited, extra data removed, and additional data added to meet the data analysis requirements.

The resultant Microsoft Excel file was then imported into version 22 of the SPSS computer analysis program. Inputting data into a computer analysis program allows for specific queries to be run on the data (Henn et al. 2006). The SPSS program was opened and the merged Microsoft Excel file was imported to create an SPSS data set for analysis. This is illustrated in Figure 16.

Figure 16: Importing the file into the SPSS program

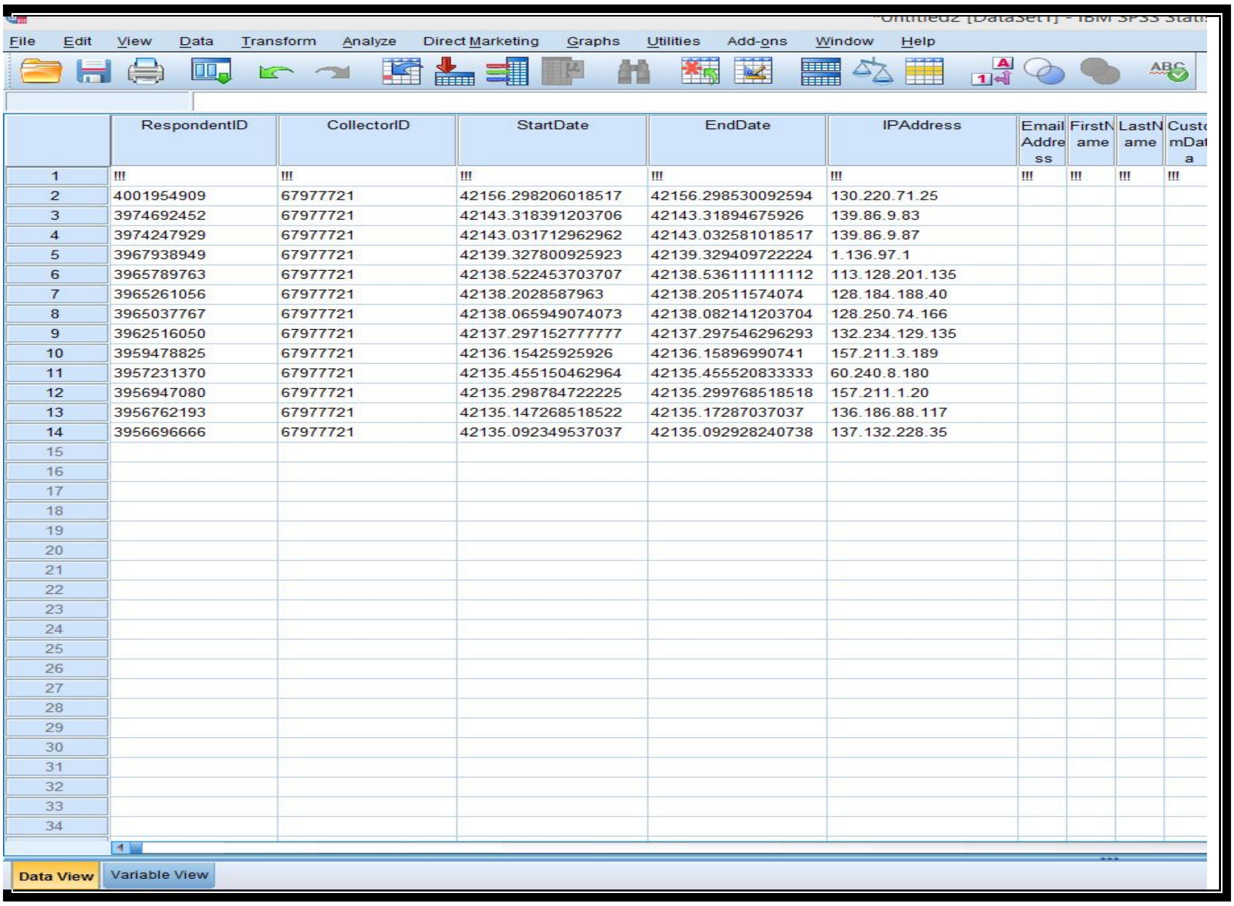


Once the file was imported into SPSS, its data was checked and additional data was entered where applicable. Data entry into the data file of a computer analytical software programme involves five steps (Tharenou et al. 2007):

1. The questionnaires received are numbered with an identification number or code;
2. The questionnaires are then checked to identify any missing data and determine if there are any questionnaires present with high levels of missing data (resulting in them being unusable);
3. Data is entered into a matrix structured in the form of columns and rows/cases, which represents variables and respondents respectively;
4. The data is coded numerically in order to facilitate the data analysis; and
5. All data is entered, where for each respondent, a specific variable is always entered in the same column, data cells contain one coded value, and missing data is presented in the form of blank cells.

The five steps outlined above were used as the guide for the data analysis process used in this research. The checking and entry of data was done in the columns and rows in the 'Data View' tab of the data file, as shown in Figure 17. For this research study, data that was not important to the analysis of the data, for example, the 'CollectorID', was removed from the data file. In addition, two major changes were made: first, the 'RespondentID' was changed to reflect the organisational codes of the researcher, and second, an additional column was added which reflected the model that the participants belonged to.

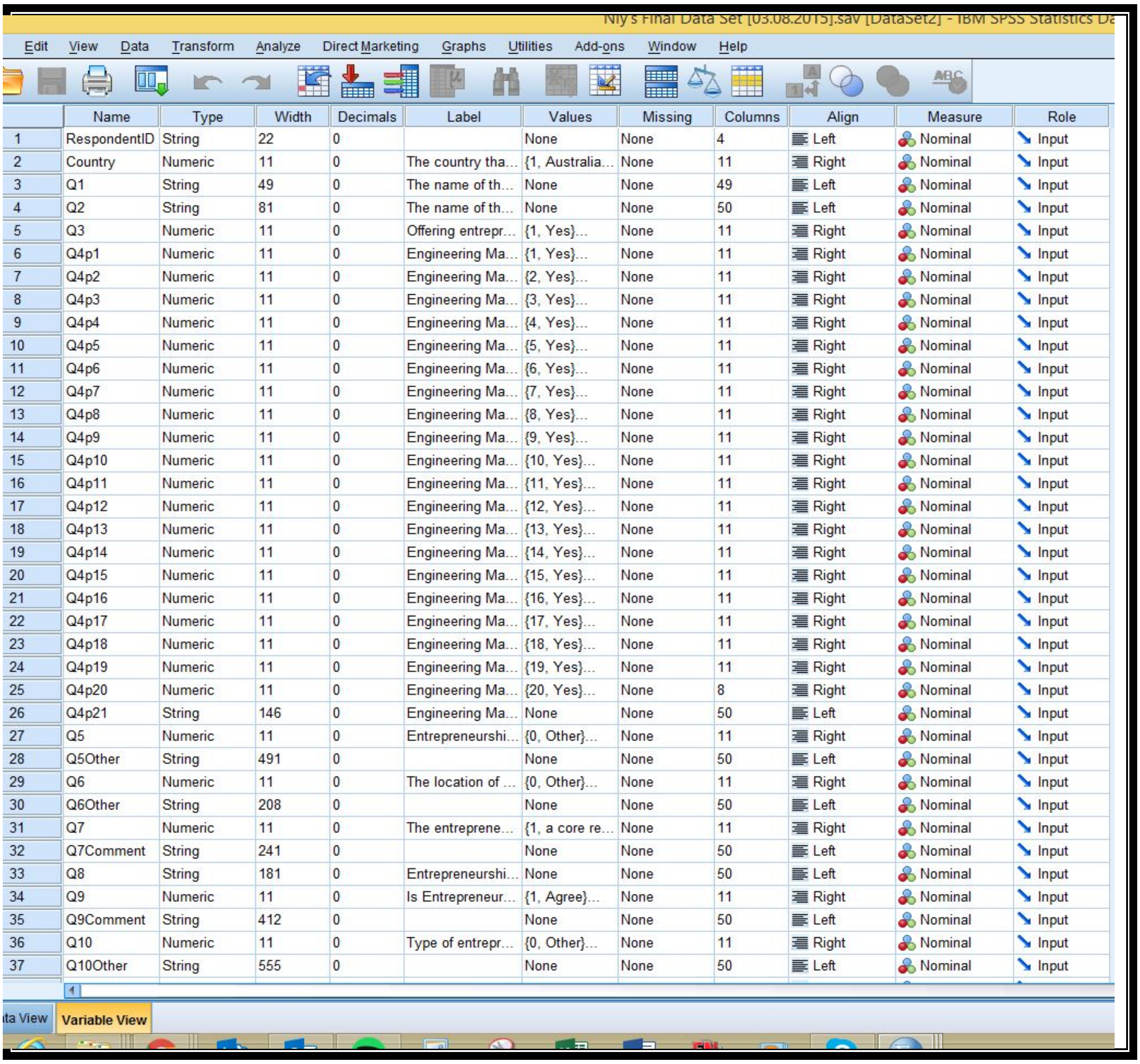
Figure 17: The 'Data View' tab of the SPSS data set



	RespondentID	CollectorID	StartDate	EndDate	IPAddress	EmailAddress	FirstName	LastName	CustomData
1	!!!	!!!	!!!	!!!	!!!	!!!	!!!	!!!	!!!
2	4001954909	67977721	42156.298206018517	42156.298530092594	130.220.71.25				
3	3974692452	67977721	42143.318391203706	42143.31894675926	139.86.9.83				
4	3974247929	67977721	42143.031712962962	42143.032581018517	139.86.9.87				
5	3967938949	67977721	42139.327800925923	42139.329409722224	1.136.97.1				
6	3965789763	67977721	42138.522453703707	42138.536111111112	113.128.201.135				
7	3965261056	67977721	42138.2028587963	42138.20511574074	128.184.188.40				
8	3965037767	67977721	42138.065949074073	42138.082141203704	128.250.74.166				
9	3962516050	67977721	42137.297152777777	42137.297546296293	132.234.129.135				
10	3959478825	67977721	42136.15425925926	42136.15896990741	157.211.3.189				
11	3957231370	67977721	42135.455150462964	42135.455520833333	60.240.8.180				
12	3956947080	67977721	42135.298784722225	42135.299768518518	157.211.1.20				
13	3956762193	67977721	42135.147268518522	42135.17287037037	136.186.88.117				
14	3956696666	67977721	42135.092349537037	42135.092928240738	137.132.228.35				

Once the data was checked and edited, the 'Variable View' tab, showed in Figure 18, was selected and relevant codes were entered to represent the data and answer options collected from the questionnaires.

Figure 18: The 'Variable View' tab of the SPSS data set



	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
1	RespondentID	String	22	0		None	None	4	Left	Nominal	Input
2	Country	Numeric	11	0	The country tha...	{1, Australia...	None	11	Right	Nominal	Input
3	Q1	String	49	0	The name of th...	None	None	49	Left	Nominal	Input
4	Q2	String	81	0	The name of th...	None	None	50	Left	Nominal	Input
5	Q3	Numeric	11	0	Offering entrepr...	{1, Yes}...	None	11	Right	Nominal	Input
6	Q4p1	Numeric	11	0	Engineering Ma...	{1, Yes}...	None	11	Right	Nominal	Input
7	Q4p2	Numeric	11	0	Engineering Ma...	{2, Yes}...	None	11	Right	Nominal	Input
8	Q4p3	Numeric	11	0	Engineering Ma...	{3, Yes}...	None	11	Right	Nominal	Input
9	Q4p4	Numeric	11	0	Engineering Ma...	{4, Yes}...	None	11	Right	Nominal	Input
10	Q4p5	Numeric	11	0	Engineering Ma...	{5, Yes}...	None	11	Right	Nominal	Input
11	Q4p6	Numeric	11	0	Engineering Ma...	{6, Yes}...	None	11	Right	Nominal	Input
12	Q4p7	Numeric	11	0	Engineering Ma...	{7, Yes}...	None	11	Right	Nominal	Input
13	Q4p8	Numeric	11	0	Engineering Ma...	{8, Yes}...	None	11	Right	Nominal	Input
14	Q4p9	Numeric	11	0	Engineering Ma...	{9, Yes}...	None	11	Right	Nominal	Input
15	Q4p10	Numeric	11	0	Engineering Ma...	{10, Yes}...	None	11	Right	Nominal	Input
16	Q4p11	Numeric	11	0	Engineering Ma...	{11, Yes}...	None	11	Right	Nominal	Input
17	Q4p12	Numeric	11	0	Engineering Ma...	{12, Yes}...	None	11	Right	Nominal	Input
18	Q4p13	Numeric	11	0	Engineering Ma...	{13, Yes}...	None	11	Right	Nominal	Input
19	Q4p14	Numeric	11	0	Engineering Ma...	{14, Yes}...	None	11	Right	Nominal	Input
20	Q4p15	Numeric	11	0	Engineering Ma...	{15, Yes}...	None	11	Right	Nominal	Input
21	Q4p16	Numeric	11	0	Engineering Ma...	{16, Yes}...	None	11	Right	Nominal	Input
22	Q4p17	Numeric	11	0	Engineering Ma...	{17, Yes}...	None	11	Right	Nominal	Input
23	Q4p18	Numeric	11	0	Engineering Ma...	{18, Yes}...	None	11	Right	Nominal	Input
24	Q4p19	Numeric	11	0	Engineering Ma...	{19, Yes}...	None	11	Right	Nominal	Input
25	Q4p20	Numeric	11	0	Engineering Ma...	{20, Yes}...	None	8	Right	Nominal	Input
26	Q4p21	String	146	0	Engineering Ma...	None	None	50	Left	Nominal	Input
27	Q5	Numeric	11	0	Entrepreneurshi...	{0, Other}...	None	11	Right	Nominal	Input
28	Q5Other	String	491	0		None	None	50	Left	Nominal	Input
29	Q6	Numeric	11	0	The location of ...	{0, Other}...	None	11	Right	Nominal	Input
30	Q6Other	String	208	0		None	None	50	Left	Nominal	Input
31	Q7	Numeric	11	0	The entreprene...	{1, a core re...	None	11	Right	Nominal	Input
32	Q7Comment	String	241	0		None	None	50	Left	Nominal	Input
33	Q8	String	181	0	Entrepreneurshi...	None	None	50	Left	Nominal	Input
34	Q9	Numeric	11	0	Is Entrepreneur...	{1, Agree}...	None	11	Right	Nominal	Input
35	Q9Comment	String	412	0		None	None	50	Left	Nominal	Input
36	Q10	Numeric	11	0	Type of entrepr...	{0, Other}...	None	11	Right	Nominal	Input
37	Q10Other	String	555	0		None	None	50	Left	Nominal	Input

Under this tab, information had to be prepared in six columns. The first column was the '*Name*' column, which was used to reflect the name of the variable. The second column was the '*Type*' column, which reflected the type of variable. The third column was the '*Width*' column, which reflected the width of the variable and the number of characters that could be entered into the rows and columns of the 'Data View' tab. The fourth column was the '*Label*' column, which reflected the description of the variable. The fifth column was the '*Value*' column, which reflected the values assigned to the variables. The final column was the '*Measure*' column, which reflected whether the measurement of the variable was nominal, where the data is categorised into two or more discrete categories, with each receiving a descriptive label and assigned a code or number (Tharenou et al. 2007), or ordinal, where the data is organised into categories which are ranked and arranged on a scale (Tharenou et al. 2007). The data already present in the data set, and additional data entered, were then edited and formatted to ensure the clarity and legibility of the total data set.

Once the data set was prepared, the data was analysed. Descriptive analyses were performed, consistent with the descriptive characteristics of the research study. The use of a descriptive analysis provided a better idea of the data collected and a basic summary of each of the variables (Henn et al. 2006). Descriptive analyses produce descriptive statistics which are used to describe the properties of a particular group and provide researchers with insight into the data (Singh 2007). Three types of analyses were performed in Phase Three. The primary analysis type performed was a bivariate analysis, which is the type of analysis performed on two variables to determine the relationship that exists (Tharenou et al. 2007). The type of bivariate analysis performed was a cross-tabulation, which is a useful approach for comparing two variables (Tharenou et al. 2007). The cross-tabulation method allows for the frequency of the cases occurring across the two variables to be reported and presented in tabular form (Singh 2007; Tharenou et al. 2007). Cross-tabulation consists of two variables – the independent variable, which creates an impact and is therefore responsible for changes occurring in another variable (i.e. the dependent variable), and the dependent variable, which is a variable affected by another variable and therefore changes only when that variable changes (i.e. the independent variable) (Given 2008; Lancaster 2007). The bivariate analysis was performed on the responses attained from closed questions with definitive responses in the questionnaire. In this research study, the bivariate analysis performed compared different variables against the models used by the participants. The second type of analysis performed was a univariate analysis, which is a preliminary analysis performed on only one variable in order to describe the sample and answer research questions based on the one variable (Tharenou et al. 2007). The results of univariate analyses are typically presented in the form of tables, charts, and graphs (Singh 2007). The majority of the research questions required a description of entrepreneurship initiatives based on the findings from one variable. The presentation in a visual form therefore allowed for the picture of entrepreneurship education for engineering undergraduates to be seen, highlighting the importance of the univariate analysis because it provided summaries of the variables analysed. Like the bivariate analysis, the univariate analysis was performed on the responses acquired from closed questions. The third type of analysis was a content analysis, similar to the content analysis performed in Phases One and Two. A content analysis was used for the open-ended questions of the questionnaire and the questions where participants were allowed the opportunity to provide additional information to explain their selected responses. The use of a content analysis helped to extract relevant themes from the participants' responses. Table 5 presents the questions asked in the online questionnaire and the types of analyses performed on the data acquired from each question.

Table 5: The topics of the questionnaire and types of analyses performed

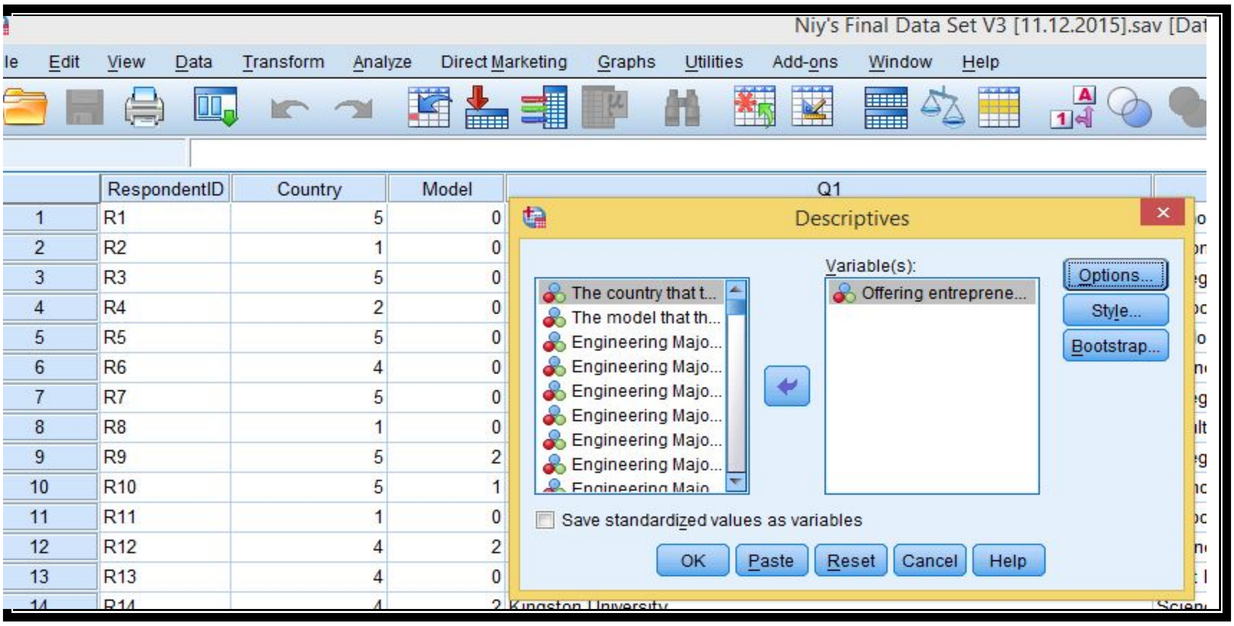
Topic Area of Questionnaire	Questionnaire Question Number	Content of Question	Analysis performed	Question Response details
Demographics	**1**	Name of the academic institution	*Not required*	
	2	Name of the school/faculty which houses the engineering programmes	*Not required*	
	3	Whether entrepreneurship initiatives are offered to engineering undergraduates	**Univariate Analysis**	Participants had to select either 'Yes' or 'No'.
	4	The engineering majors offered by the academic institution	*Not required*	
How entrepreneurship is combined with engineering	**7**	Whether entrepreneurship initiatives are compulsory or optional	**Univariate Analysis**	Participants had to state whether their entrepreneurship initiatives were compulsory or optional.
			Content Analysis	Participants had to provide information to explain and elaborate on their selection.
	8	Whether the academic institution is associated with entrepreneurship-based affiliates	**Content Analysis**	Participants had to list all of the entrepreneurship foundations, networks, or initiatives that their institution was associated with.
	9	Whether entrepreneurship is "well-supported" at the academic institution	**Univariate Analysis**	Participants had to state whether they agreed or disagreed.
			Content Analysis	Participants had to explain the reason behind their selection.
The structure of the entrepreneurship initiatives	**5**	What led to the creation of the academic institution's entrepreneurship initiatives	**Bivariate Analysis**	A cross-tabulation was performed to determine which of the 10 choices were selected by participants following each model.
	6	The location of the entrepreneurship initiatives	**Bivariate Analysis**	A cross-tabulation was performed to determine which of the 5 choices were selected by participants following each model.

The structure of the entrepreneurship initiatives	**10**	What is offered in the academic institution's entrepreneurship initiatives	**Univariate Analysis**	Participants had to select only one option from 3 possible choices.
	11	Name and description of the academic institution's entrepreneurship programme for engineering undergraduates	**Content Analysis**	Participants had to provide details of the entrepreneurship programme their engineering undergraduates participated in.
	12	Duration of the entrepreneurship programme for engineering undergraduates	**Univariate Analysis**	Participants had to select all applicable options from 3 different choices.
	14	What engineering undergraduates experience in entrepreneurship initiatives	**Bivariate Analysis**	A cross-tabulation was performed to determine which of the 7 choices were selected by participants following each model.
	15	The target students for the entrepreneurship initiatives	**Bivariate Analysis**	A cross-tabulation was performed to determine which of the 5 choices were selected by participants following each model.
	18	Type of faculty teaching the courses in the entrepreneurship programme	**Bivariate Analysis**	A cross-tabulation was performed to determine which of the 6 choices were selected by participants following each model.
	19	The schools in which the entrepreneurship teaching faculty are located	**Bivariate Analysis**	A cross-tabulation was performed to determine which of the 5 choices were selected by participants following each model.
	21	Where entrepreneurship courses for engineering undergraduates are delivered	**Bivariate Analysis**	A cross-tabulation was performed to determine which of the 5 choices were selected by participants following each model.
The content of the entrepreneurship initiatives	**13**	The objectives of the entrepreneurship programme for engineering undergraduates	**Content Analysis**	Participants had to state the objectives of their entrepreneurship programme for engineering undergraduates.
	16	The learning outcomes of the entrepreneurship programme for engineering undergraduates	**Bivariate Analysis**	A cross-tabulation was performed to determine which of the 3 choices were selected by participants following each model.

	17	The entrepreneurship competencies emphasised in the entrepreneurship programme for engineering undergraduates	**Bivariate Analysis**	A cross-tabulation was performed where the level of emphasis placed on each of the Morris et al. (2013) competencies was determined for the participants following each model.
	22	The curriculum used in the entrepreneurship programme for engineering undergraduates	**Bivariate Analysis**	A cross-tabulation was performed to determine which of the 3 choices were selected by participants following each model.
	23	The schools responsible for the development of the curriculum used in the entrepreneurship programme for engineering undergraduates	**Bivariate Analysis**	A cross-tabulation was performed to determine which of the 7 choices were selected by participants following each model.
The content of the entrepreneurship initiatives	**24**	The entrepreneurship opportunities provided by the academic institution for engineering undergraduates	**Bivariate Analysis**	A cross-tabulation was performed to determine which of the 11 choices were selected by participants following each model.
	25	The entrepreneurship co-/extra-curricular activities offered by the academic institution to engineering undergraduates	**Content Analysis**	Participants had to state the different entrepreneurship co- and extra-curricular activities for engineering undergraduates that their institutions offered.
	28	What engineering undergraduates are encouraged to do upon graduation	**Bivariate Analysis**	A cross-tabulation was performed to determine which of the 7 choices were selected by participants following each model.
	29	What the academic institution offers to their alumni after graduation	**Bivariate Analysis**	A cross-tabulation was performed to determine which of the 5 choices were selected by participants following each model.

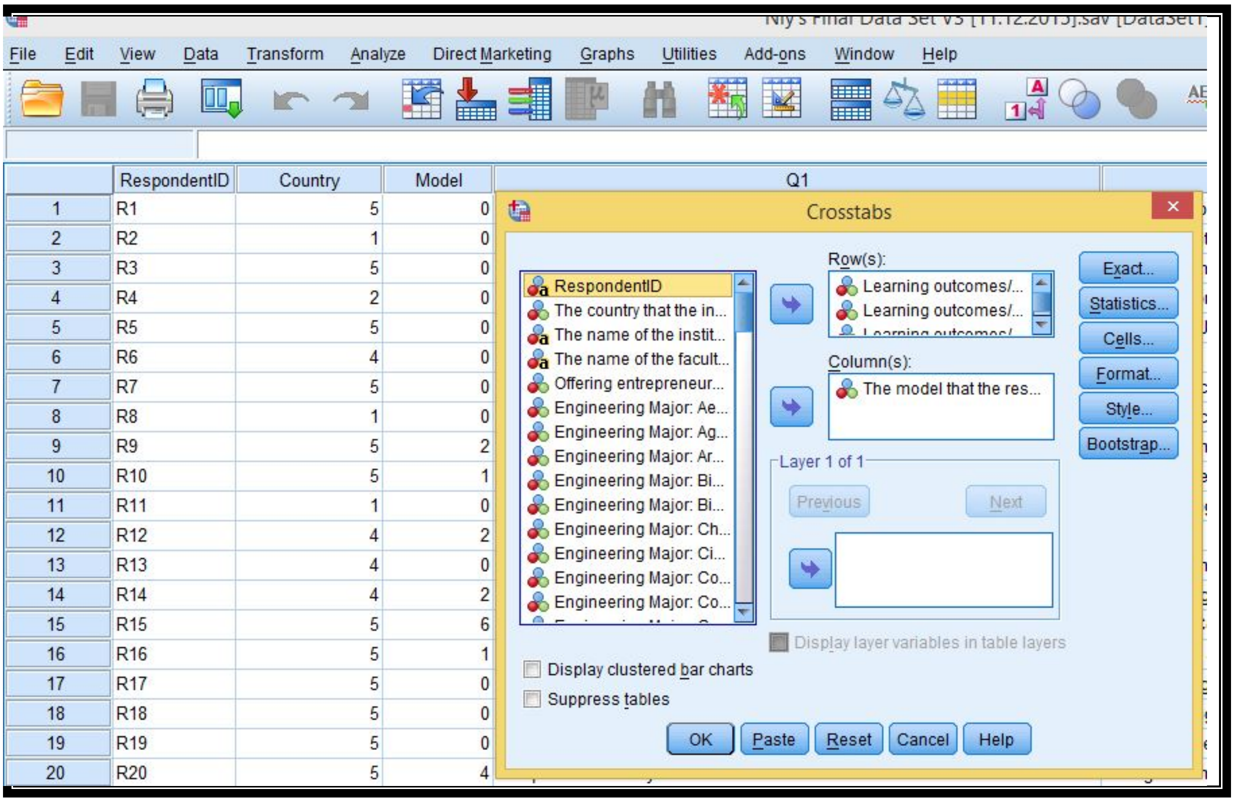
To perform the univariate descriptive analysis in SPSS, the ‘Analyze’ option was first selected, followed by ‘Descriptive Statistics’, and then ‘Descriptives’, which generated the box showed below in Figure 19.

Figure 19: Performing a descriptive analysis for single variables in the SPSS program



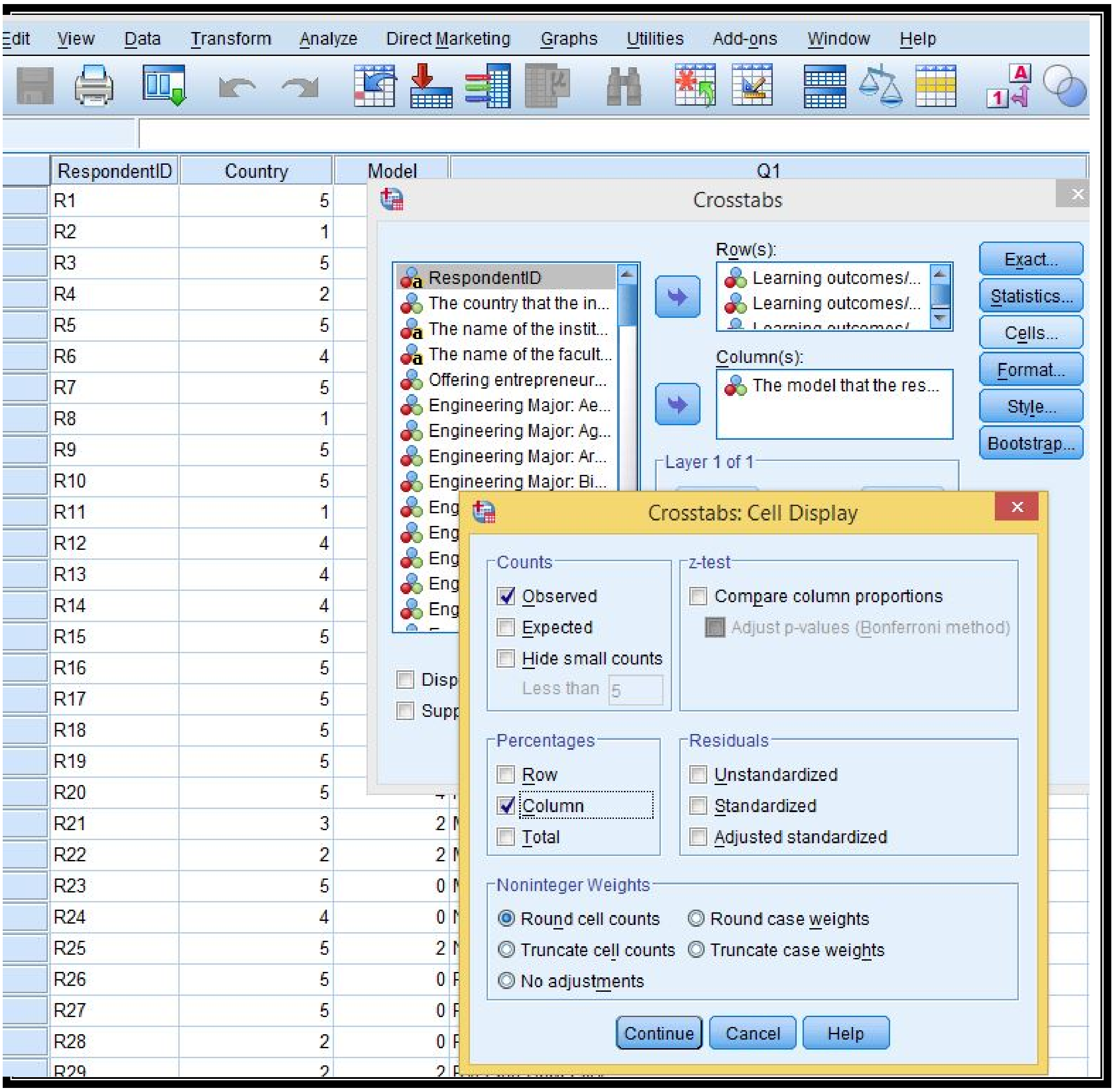
The variable that the analysis was performed on was selected from the list on the left and placed in the ‘Variable(s)’ section on the right by clicking on the arrow in the middle, as shown in Figure 19. For each cross-tabulation performed, the independent variable, which remained constant during the data analysis process, was the models used by the participants for educating engineering undergraduates about entrepreneurship. This demonstrated that the purpose of cross-tabulations was to make comparisons amongst the models. To perform this action in SPSS, the ‘Analyze’ option was selected, followed by ‘Descriptive Statistics’, and then ‘Crosstabs’, which generated the box shown in Figure 20.

Figure 20: Performing a descriptive analysis for two variables using crosstabs in the SPSS program



The independent and dependent variables were then selected from the column on the left of the crosstabs box shown in Figure 20. The relevant variables were placed in the 'Row' and 'Column' sections by clicking on the arrows in the middle. In addition to these selections, it was necessary to click on the 'Cells' button, which generated the box shown in Figure 21.

Figure 21: Additional selections for crosstab analyses



If the independent variable was placed in the 'Column' box, the 'Column' percentage was selected, and if the dependent variable was placed in the 'Column' box, the 'Row' percentage was selected. The data descriptions were enhanced by using diagrams, which were used to visually display the data to gain a more explicit understanding of the data. Here, pie charts, bar charts and tables were used.

The results of the three phases were then combined to identify and describe the typology of models used by tertiary-level academic institutions to educate engineering undergraduates about entrepreneurship and paint an overall picture of entrepreneurship education for engineering students and the typology of models. Therefore, using this mixed methods research design, it was possible to analyse both the qualitative and quantitative data sets independently of each other, and then mix the data at the interpretation stage (Leech & Onwuegbuzie 2009).

4.8: Data Quality

Data quality in mixed methods is determined by what constitutes good quality data in both qualitative and quantitative research (Teddlie & Tashakkori 2009). As a result, two different sets of quality standards are required in mixed methods research – one for qualitative research and one for quantitative research (Teddlie & Tashakkori 2009). Data quality in qualitative research means investigating how trustworthy the data is (Teddlie & Tashakkori 2009). According to Lincoln and Guba (1985), there are four criteria, that must be present in order for qualitative data to be considered trustworthy – it must be credible (i.e. the believability of the findings), transferable (i.e. the application of the findings to other contexts), dependable (i.e. the applicability of the findings at other times), and confirmable (i.e. preventing the intrusion of the researcher’s values to a high degree). Data quality in quantitative research, on the other hand, focuses on measurement and whether the data that has been acquired represents the constructs they were designed to capture and measure (Teddlie & Tashakkori 2009).

Data quality is measured in terms of two constructs: data reliability and data validity (Bloor & Wood 2006; Eriksson & Kovalainen 2008; Stokes 2011; Teddlie & Tashakkori 2009). Data reliability refers to whether or not the acquired data is consistently and accurately representative of the constructs that are being examined (Teddlie & Tashakkori 2009). In other words, data reliability deals with the question about whether or not a research study will produce the same results if replicated (Bloor & Wood 2006; Bryman & Bell 2011; Eriksson & Kovalainen 2008; Stokes 2011). Data validity, on the other hand, refers to whether or not the data acquired is representative of the constructs they were believed to capture (Teddlie & Tashakkori 2009). It therefore relates to whether or not the research achieved what it was supposed to achieve and whether or not the findings are believable (Stokes 2011). This section focuses on the steps taken to ensure the reliability and validity of this mixed methods research study.

4.8.1: Data Reliability

Reliability in qualitative research plays a much smaller role when compared to quantitative research and is used to demonstrate that the approach used by the researcher is consistent across different researchers and projects (Gibbs 2007). It generally relates to the reliability of multiple coders on a team agreeing on the codes used, or in other words, it is more about comparing coding among several coders (Creswell & Plano Clark 2011).

Two of the techniques proposed by (Gibbs 2007) were used to ensure the reliability of the qualitative data in this research study. These techniques were also used to ensure the reliability of the quantitative data given the descriptive nature of the research study. First, the documents that contained data collected from the academic institutions' webpages went through three rounds of checks to remove or change any mistakes identified. This involved revisiting the institutions' webpages and ensuring that the data in the documents matched the information provided on the webpages. This comparison between the documents and the webpages allowed for clarification of the data. Second, it was necessary to continuously check the coding and associated definitions that were used throughout both analytical processes. The purpose of doing this was to ensure that the definitions that were used remained unchanged and that the data had been coded correctly. Furthermore, to improve the reliability of data, continuous notes were taken and documented in Microsoft Word documents, Microsoft Excel spread sheets, and memos within the N-Vivo software programme to create a record which allow others to potentially follow the same processes if future research were to be undertaken (Bloor & Wood 2006).

4.8.2: Data Validity

Validity deals with the integrity of the conclusions derived from a piece of research (Bryman & Bell 2011). In a mixed methods research context, validity is the use of strategies or techniques that allow the issues that may potentially arise during the data collection, analysis and interpretation stages that potentially affect how the qualitative and quantitative phases are connected and the conclusions that can be drawn are addressed (Creswell & Plano Clark 2011). Validity in mixed methods research applies to both qualitative and quantitative approaches (Onwuegbuzie & Johnson 2006; Tashakkori & Teddlie 1998); as well as to the different stages of the research process including research design, data collection, data analysis, and data interpretation (Onwuegbuzie & Johnson 2006). Both quantitative and qualitative validity were important to this research. Quantitative validity deals with scores that are received from research subjects being meaningful indicators of the construct that is being measured (Creswell & Plano Clark 2011); while qualitative validity is about determining whether or not the findings concluded are accurate from the view of the researcher, participants, and audience (Creswell & Miller 2000). Given that this was a mixed methods study, both types of validity had to be considered.

In qualitative research, there is greater focus on validity in order to determine whether the data gathered is accurate, trustworthy, and credible (Lincoln & Guba 1985). Establishing and checking for qualitative validity requires an assessment of whether or not the data that has been collected is accurate, which typically requires the use of a number of different strategies (Creswell & Miller 2000; Creswell & Plano Clark 2011; Gibbs 2007). For qualitative validity to occur, the decision was made to employ two of the eight strategies proposed by Creswell and Miller (2000), and a third strategy described by Lincoln and Guba (1985).

First, rich descriptions were provided, which enable findings to be conveyed and detailed descriptions of the setting to be generated (Creswell & Miller 2000). The purpose of this is to make the results richer and more realistic, thereby enhancing the validity of the findings (Creswell & Miller 2000). In this research study, detailed descriptions of the models used by tertiary-level academic institutions to educate engineering undergraduates in each country were provided. Second, within these descriptions, discrepant information running counter to broad themes and characteristics of each model was also presented. To do this, the researcher discusses the evidence of a theme, and then presents trends and all contradictory data as a way of making the description more realistic and valid (Creswell & Miller 2000). For the model descriptions, everything was presented, including all occurrences found and all exceptions to the norm. Third, a variation of the reflexive journal technique, described by Lincoln and Guba (1985), was used. This technique involves the use of a diary where records of information related to self and method are kept (Lincoln & Guba

1985). Here, information about the method used, and information collected from the various institution webpages were continuously documented throughout the qualitative data collection and analysis stages. The decisions made regarding, for example, categorisation of institutions and their entrepreneurship initiatives were also documented, particularly justifications for categorisation choices made. This also acted as a set of guidelines that were used for categorisation choices, which was continuously checked to ensure that all units involved in the research study were placed in the correct categorises and assigned the correct models. This method was shown to be the most appropriate way of ensuring the quality of data because it was a technique that ensured that the data possessed all four criteria of credibility, transferability, dependability, and conformability, to be identified as trustworthy. From the quantitative perspective, divergent or discriminant validity – the degree to which measurement outcomes differentiate groups who are expected to be different on a particular attribute (Teddlie & Tashakkori 2009) – was selected because was selected because one of the research purposes was to describe different models, where any similarities and resulting differences were highlighted.

In addition, it was important to determine the validity of the conclusions made in order to avoid or reduce any threats to internal and external validity (Creswell & Plano Clark 2011). Internal validity is the extent to which researchers can conclude the presence of a cause-and-effect relationship amongst the variables (Creswell & Plano Clark 2011). Given that cause-and-effect relationships were outside the scope of this research project, the focus on internal validity was eliminated. However, external validity – which is the extent to which researchers are able to conclude that all results are applicable to a larger population; something that is of high concern for survey research (Creswell & Plano Clark 2011) – was applicable to this research study. One of the threats to external validity is generalizability (Creswell 2014). In this research study, there was first an issue of generalizability as it pertained to the institutions included in the Phase One sample. A further issue, with regards to generalizability, was the inability to generalize findings to academic institutions present in other countries. This research focused on five countries and highlighted the differences that existed amongst these countries based on the selected sample. Considering the scope of this research study, it was impossible to determine whether there are similar findings in other countries. Future research in other countries, and potentially in other contexts, would need to be carried out in order to determine if similar findings exist. As seen, several approaches were taken to ensure the validity of the data and obtained findings in order to provide strong support for what has been proposed in this research study.

4.9: Ethical Considerations

In order to carry out this research study, it was necessary to apply to the university's ethics committee before commencing the study. The study was approved through the University of Tasmania's Social Sciences Human Research Ethics Committee (approval number H0014579). As stated in section 4.7.2, an email was sent to deans or other senior officers of engineering schools at tertiary-level academic institutions included in the population that offered accredited undergraduate engineering programmes. This email provided the following information:

- the background of the issue being investigated;
- the purpose of the research study;
- the questionnaire details;
- the link to the questionnaire on Survey Monkey (www.surveymonkey.net);
- information about how the completion of the online questionnaire would benefit the research study and the overall area of investigation;
- alternatives to completing the questions listed in the questionnaire if potential respondents were unable to complete the questionnaire online; and
- information pertaining to opportunities that were available for participants to request the findings of the study.

Included as an attachment to the email was a participant information sheet, which outlined details about the purposes of the research study, the requirements of potential participants, the benefits and risks from participation, what happened if participants decided to withdraw from the study, what would happen to the collected information on completion of the study, the publishing of the results, and contact information for the researchers involved in the study and the Human Research Ethics Committee of the University of Tasmania. Confidentiality and anonymity were clearly addressed, with potential participants being assured that they would receive both confidentiality and anonymity in their responses. In addition, potential research participants were offered the opportunity to contact any of the researchers with regards to any questions or concerns that they potentially could have. No issues arose with this and participants did not contact any of the researchers regarding any privacy issues. In addition, no participant approached the Human Research Ethics Committee with any issues of concern.

4.10: Chapter Summary

This chapter reported on the methodological considerations associated with this research study. As discussed, this study had four objectives which were to identify the models used by tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States to educate engineering undergraduates about entrepreneurship, to provide descriptions about each of these models, and to determine the relevance of the Standish-Kuon and Rice (2002) typology for describing and categorising entrepreneurship initiatives for engineering undergraduates. In this research study, pragmatist and positivist paradigms were adopted. To satisfy the research objectives, a mixed methods approach was selected, due to the focus placed on the research questions and the allowance for the collection and analysis of both qualitative and quantitative data. The study was structured into a multiphase design. This design was a Partially Mixed Sequential Dominant Status design, which allowed for data to be collected and analysed in one phase before the subsequent phase could be initiated, greater emphasis to be placed on either the qualitative or quantitative part of the study (in the case of this research study, the qualitative part), and both the qualitative and quantitative findings are mixed at the interpretation stage.

The final research design consisted of three phases. In Phase One, the secondary data that was collected and analysed allowed for insight into how academic institutions in the United States educate engineering undergraduates about entrepreneurship, and the models that were used for these purposes. In Phase Two, the secondary data collected and analysed allowed for insight into how academic institutions in Australia, Canada, New Zealand, and the United Kingdom educated engineering undergraduates about entrepreneurship, and the models used by these institutions. In Phase Three, the primary data collected and analysed provided additional information about entrepreneurship education for engineering undergraduates, and additional data for the description of the models identified in Phases

One and Two. On completion of Phase Three, the findings from the three phases were combined and analysed in order to address the research objectives and research questions.

The thesis will now continue with Chapter 5, which presents the first group of findings from the research study.

Chapter 5: Research Findings Part I

5.1: Introduction

Chapter 5 presents a discussion of the prevalence of entrepreneurship education for engineering undergraduates in Australia, Canada, New Zealand, the United Kingdom, and the United States. Next, it provides information regarding the support provided for the development of entrepreneurship education, how entrepreneurship has been integrated within the undergraduate engineering curriculum, and the entrepreneurship competencies that are deemed necessary for engineering undergraduates. The section then concludes with information about entrepreneurship initiatives for engineering undergraduates offered by institutions in each of these countries. More specifically, it contains information about the objectives of the initiatives, the types of educational programmes, the practical experiences, and the opportunities offered within the initiatives, and the outcomes of the initiatives.

5.2: The prevalence of entrepreneurship education for engineering undergraduates in Australia, Canada, New Zealand, the United Kingdom, and the United States.

As explained in Chapter Four, this study examined the educational initiatives offered to engineering undergraduates by 600 tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States with accredited undergraduate engineering programmes. To determine the prevalence of undergraduate engineering programmes that included entrepreneurship education, the webpages outlining the structure of undergraduate engineering programmes for each institution were reviewed to determine whether opportunities for students to learn about entrepreneurship were provided.

Table 6: The presence of entrepreneurship education for engineering undergraduates in Australia, Canada, New Zealand, the United Kingdom, and the United States

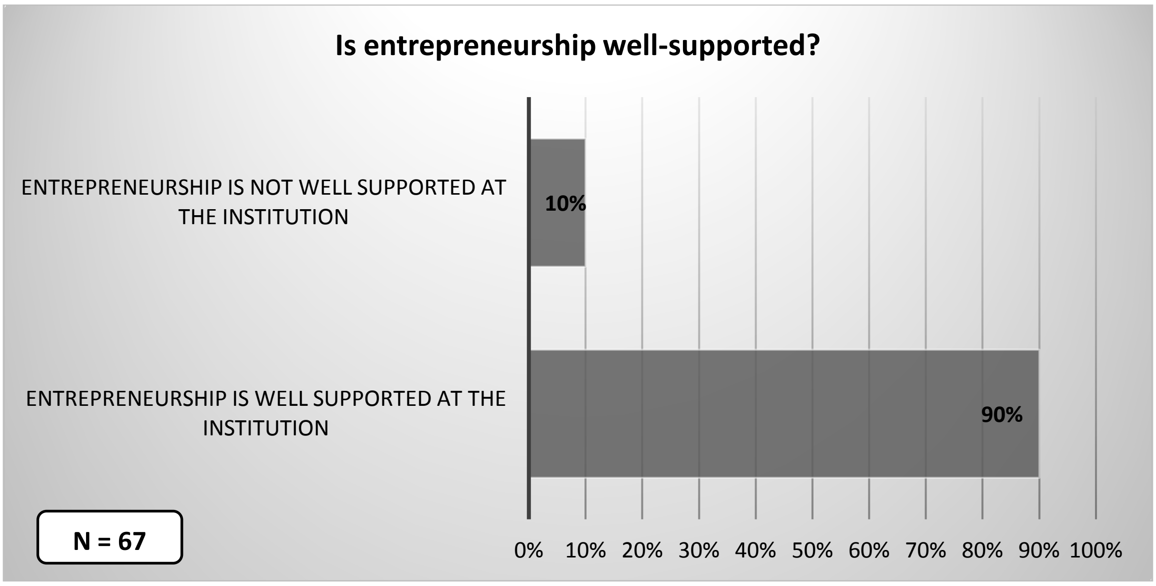
The presence of entrepreneurship education for engineering undergraduates in Australia, Canada, New Zealand, the United Kingdom, and the United States.						
	Australia	**Canada**	**New Zealand**	**The United Kingdom**	**The United States**	**Total**
Total number of institutions with accredited undergraduate engineering programmes	36	42	8	100	414	**600**
Total number of institutions offering entrepreneurship education to engineering undergraduates	13	24	5	36	203	**281**
Percentage of institutions offering entrepreneurship education to engineering undergraduates	36%	57%	62.5%	36%	49%	**47%**

As shown in Table 6, close to half of the 600 institutions reviewed in this research educated their engineering undergraduates to be entrepreneurial. The findings showed that academic institutions offering opportunities for engineering undergraduates to learn about entrepreneurship are now more prevalent in Canada and New Zealand. In the United States, the number of institutions appears equally prevalent. In Australia and the United Kingdom, however, they are currently the exception as opposed to the norm. This meant that overall there is an indication of a strong presence of entrepreneurship in undergraduate engineering.

5.3: The support provided for entrepreneurship education development

To determine the level of support that institutions provided for the development of entrepreneurship education, the online questionnaire sent to engineering school administrators asked respondents to first indicate whether they felt entrepreneurship was “well-supported” by their home institutions. Support, in this context, referred to, for example, the provision of the necessary resources for entrepreneurial learning to occur, whether the institution considered it valuable for students to acquire entrepreneurial abilities, or whether the institution actively promoted participation in entrepreneurship educational programmes. Figure 22 shows engineering administrators’ views on whether they consider entrepreneurship to be well-supported at institutions that offer entrepreneurship education to engineering undergraduates.

Figure 22: Engineering school administrators' views on whether entrepreneurship is well-supported at their tertiary-level academic institutions



As presented in Figure 22, 90% of the sixty-seven respondents who answered this question on the online questionnaire reported that they felt entrepreneurship was well-supported at their institutions.

Engineering school administrators were further asked to explain the reasons for stating whether or not they felt entrepreneurship was "well-supported". Analysis of the qualitative data obtained from these open-ended responses identified two reasons. First, it was noted that entrepreneurship was increasing in importance in both the business and engineering schools. For example, respondents R80 and R95 stated:

Respondent R80	*"The School of Management has an Entrepreneurship Center with a Director. In addition the Engineering School received 1.6 million dollars from both the State and Federal govts"*
Respondent R95	*"Entrepreneurship is an emerging priority in the business school and within some of our engineering undergraduate and graduate programs"*

Second, it was noted that besides becoming important to the engineering and business schools, entrepreneurship was becoming important to the institution on a whole. For example, respondents R20, R41, R98, and R101 stated:

Respondent R20	*"Now it is. We now have a president who supports such initiatives and a way of thinking."*
Respondent R41	*"Big efforts are addressed to promote an entrepreneurial ecosystem in the university."*
Respondent R98	*"It is a university priority that is evolving."*
Respondent R101	*"Active programs and encouragement. One of the Universities strategic focuses."*

In contrast to the positive views provided, some respondents stated that although they agreed entrepreneurship was "well-supported" by the institution, more could be done to develop entrepreneurship education. For example, respondents R61, R85, and R90 stated:

Respondent R61	*"It is an active program, but funds are limited."*
Respondent R85	*"Generally, I agree, but our entrepreneurship opportunities could be better coordinated."*
Respondent R90	*"Could do more."*

Concurrently, there was a level of disagreement, with 10% of respondents stating that entrepreneurship was not "well-supported" by their institutions. When the qualitative responses were analysed to identify the reasons why respondents felt it was not "well-supported", two key reasons emerged. First, it was noted that although entrepreneurship was supported, it was not uniformly supported throughout all areas of the discipline. This was illustrated from the response by respondent R88, who stated:

> *"I think we support some aspects of entrepreneurship well, but could be better with other aspects."*

Second, it was noted that the focus was not specifically on entrepreneurship, but on engineering as a whole. This idea stemmed from respondent R21, who stated:

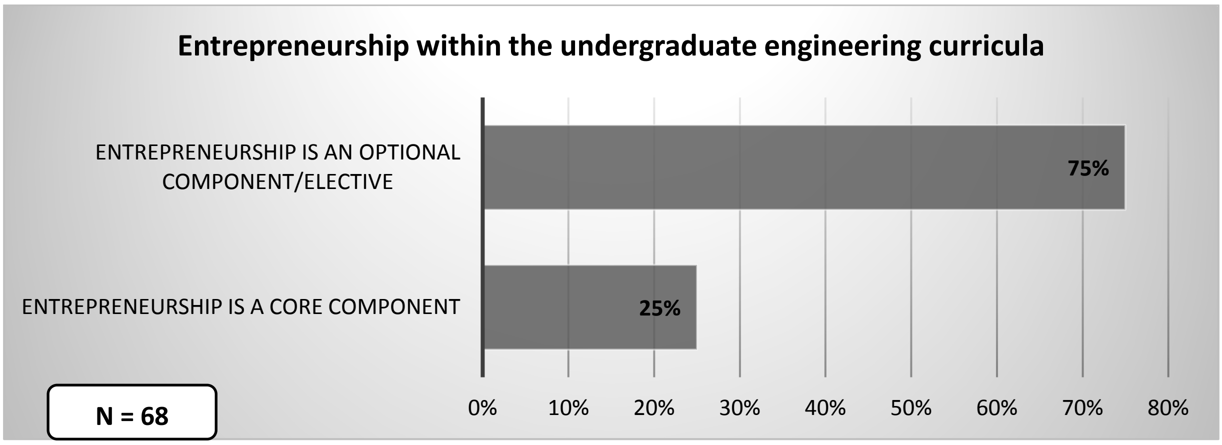
> *"The investment is in the programme as a whole and not entrepreneurship per se."*

Despite the recognition that there are opportunities to improve the support for entrepreneurship provided in some institutions, the findings overall demonstrated that entrepreneurship is perceived as being well-supported in institutions that offer entrepreneurship initiatives to engineering undergraduates.

5.4: The integration of entrepreneurship into the undergraduate engineering curriculum

To determine how entrepreneurship was integrated into the undergraduate engineering curriculum, the online questionnaire asked engineering school administrators to state whether entrepreneurship was a core, compulsory component of the undergraduate engineering curriculum, or an optional, elective programme that complements undergraduate engineering degrees. The results of the analysis are presented in Figure 23.

Figure 23: Details about whether entrepreneurship is a compulsory or optional component of the undergraduate engineering curricula



As presented in Figure 23, 75% of the sixty-eight engineering school administrators who responded to this question stated that their initiatives were optional components which complemented engineering degrees. This demonstrates that entrepreneurship is primarily an optional elective component added to engineering degrees.

The engineering school administrators were further asked to provide a comment explaining their choice. From the analysis of the open-ended responses received, three additional findings emerged. First, optional components were becoming compulsory. One engineering school administrator, respondent R124, stated:

"We plan to make these activities mandatory"

This statement illustrates that the initiatives at this respondent's institution were moving away from being optional towards becoming a core component of the engineering undergraduate curriculum.

Second, an issue of uniformity arose. Two engineering school administrators, respondent R10 and R12 stated:

Respondent R10	*"Integrated into some courses and programs, but not all"*
Respondent R12	*"Not uniform throughout all 9 departments however this is the intention"*

These comments illustrate that entrepreneurship was integrated into some engineering degrees, but not all.

Third, entrepreneurship was shown to either be a core component of some undergraduate engineering degrees, or a core component in some levels of undergraduate engineering degrees. Respondent R44 stated:

"Core requirement of the MEng degrees but not for the BEng degrees"

Respondent R62, on the other hand, stated:

"It was core prior to 2014/15, but is now introduced within the Year 1 core and offered as an optional module in Year 2. Students progressing to year 3 of Engineering and Business Studies can access further modules within the Business School"

Overall, although the findings demonstrated that entrepreneurship education is an important component of engineering undergraduate degrees, it is still primarily an option that students can select to enhance their degrees. This shows that engineering students primarily are able to decide whether or not they want to acquire entrepreneurial capabilities. The majority of the institutions that participated in the online questionnaire are providing flexibility for students to choose to develop such capabilities, as opposed to making entrepreneurship core requirements of their degrees.

5.5: The competencies required for engineering undergraduates to be entrepreneurial

As explained in section 2.3.2, there are 13 competencies individuals must possess in order to be considered entrepreneurial (Morris et al. 2013b). The online questionnaire sent to engineering school administrators asked respondents to rate, on a five-point Likert scale, the level of emphasis placed on each of these competencies. The five-point scale ranged from '*No emphasis*', '*Some emphasis*', '*Moderate emphasis*', '*Major emphasis*', to '*Significant emphasis*'. A factor analysis was performed on the data to determine, based on the views of engineering administrators, which of the 13 competencies were perceived as necessary for engineering undergraduates to possess in order to be considered entrepreneurial.

The 13 competencies were subjected to Maximum Likelihood Factoring (ML) using SPSS version 22. Prior to performing ML, the suitability of data for factor analysis was assessed. Inspection of the correlation matrix, shown in Table 7, revealed the presence of many coefficients of 0.5 and above.

Table 7: The Correlation Matrix of the entrepreneurship competencies explored

Correlation	**Entrepreneurial Competencies**												
Entrepreneurial Competencies	Opportunity Recognition	Opportunity Assessment	Risk Management/ Mitigation	Conveying a Compelling Vision	Tenacity/ Perseverance	Creative Problem Solving/ Imaginativeness	Resource Leveraging	Guerrilla Skills	Value Creation	Maintain Focus yet Adapt	Resilience	Self-Efficacy	Building and Using Networks
Opportunity Recognition	1.000	.654	.482	.663	.585	.530	.414	.467	.513	.413	.390	.537	.349
Opportunity Assessment	.654	1.000	.634	.656	.643	.535	.636	.572	.579	.549	.503	.628	.632
Risk Management/ Mitigation	.482	.634	1.000	.527	.556	.377	.564	.516	.483	.455	.350	.491	.494
Conveying a Compelling Vision	.663	.656	.527	1.000	.688	.449	.647	.667	.526	.623	.674	.602	.453
Tenacity/ Perseverance	.585	.643	.556	.688	1.000	.685	.705	.519	.582	.574	.670	.705	.558
Creative Problem Solving/ Imaginativeness	.530	.535	.377	.449	.685	1.000	.438	.230	.645	.330	.390	.683	.655
Resource Leveraging	.414	.636	.564	.647	.705	.438	1.000	.665	.489	.693	.685	.623	.485
Guerrilla Skills	.467	.572	.516	.667	.519	.230	.665	1.000	.463	.717	.691	.607	.325
Value Creation	.513	.579	.483	.526	.582	.645	.489	.463	1.000	.519	.547	.748	.630
Maintain Focus yet Adapt	.413	.549	.455	.623	.574	.330	.693	.717	.519	1.000	.779	.690	.437
Resilience	.390	.503	.350	.674	.670	.390	.685	.691	.547	.779	1.000	.711	.410
Self-Efficacy	.537	.628	.491	.602	.705	.683	.623	.607	.748	.690	.711	1.000	.640
Building and Using Networks	.349	.632	.494	.453	.558	.655	.485	.325	.630	.437	.410	.640	1.000

The Kaiser-Meyer-Olkin (KMO) Test and Bartlett's Test of Sphericity were then performed, with the KMO test used to determine the suitability of the data for factory analysis, and the Bartlett's Test of Sphericity, used to show the validity and suitability of the responses collected to the problem being addressed (Pallant 2011). The results of the two tests are shown in Figure 24.

Figure 24: The results of the Kaiser-Meyer-Olin Test and Bartlett's Test of Sphericity

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.911
Bartlett's Test of Sphericity	Approx. Chi-Square	504.514
	df	78
	Sig.	.000

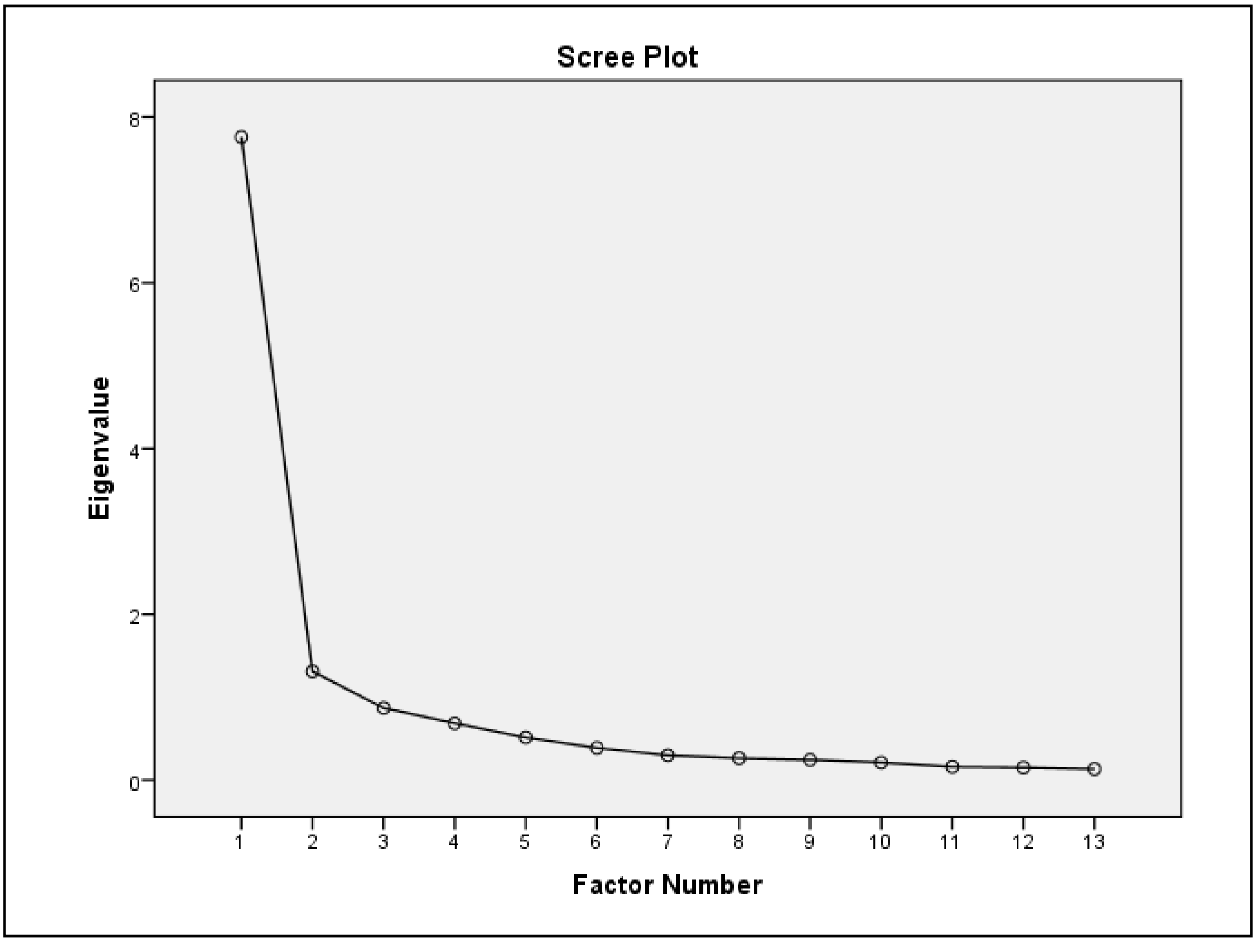
The Kaiser-Meyer-Olkin value was 0.91, exceeding the recommended minimum value of 0.6 and Bartlett's Test of Sphericity reached statistical significance supporting the factorability of the correlation matrix (Pallant 2011). Maximum Likelihood Factoring revealed the presence of two factors with eigenvalues exceeding 1, shown in Table 8.

Table 8: The Total Variance explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.758	59.674	59.674	7.379	56.758	56.758	4.489	34.531	34.531
2	1.312	10.095	69.770	1.055	8.114	64.872	3.944	30.341	64.872
3	.871	6.699	76.469						
4	.686	5.275	81.744						
5	.515	3.958	85.702						
6	.388	2.983	88.685						
7	.300	2.308	90.994						
8	.265	2.041	93.035						
9	.245	1.888	94.923						
10	.213	1.637	96.560						
11	.161	1.238	97.798						
12	.152	1.170	98.968						
13	.134	1.032	100.000						

This explained 59.7% and 10.1% of the variance respectively, which together explained a total of 69.8% of the variance. To further confirm this, an inspection of the scree plot, shown in Figure 25, revealed a clear break after the second factor. This supported the decision to retain these two factors for further investigation.

Figure 25: The Scree Plot illustrating the Total Variance



To aid in the interpretation of these two factors, Varimax Rotation was performed. The Varimax Rotation method refers to the attempt made to minimise the number of variables that have high loadings on each factor (Pallant 2011). The rotated solution revealed the presence of a simple structure, with both factors showing a number of strong loadings on more than half of the variables, as shown in Table 9.

Table 9: Results of the Rotated Factor Matrix showing the entrepreneurial competencies required by engineering students

Rotated Factor Matrix[a]

	Factor	
	1	2
Entrepreneurial Competencies: Guerrilla Skills	.845	.165
Entrepreneurial Competencies: Maintain Focus yet Adapt	.811	.271
Entrepreneurial Competencies: Resilience	.777	.330
Entrepreneurial Competencies: Resource Leveraging	.715	.393
Entrepreneurial Competencies: Conveying a Compelling Vision	.685	.420
Entrepreneurial Competencies: Self-Efficacy	.569	.666
Entrepreneurial Competencies: Opportunity Assessment	.539	.554
Entrepreneurial Competencies: Tenacity/Perseverance	.525	.665
Entrepreneurial Competencies: Risk Management/Mitigation	.482	.403
Entrepreneurial Competencies: Value Creation	.404	.666
Entrepreneurial Competencies: Opportunity Recognition	.400	.527
Entrepreneurial Competencies: Building and Using Networks	.278	.692
Entrepreneurial Competencies: Creative Problem Solving/Imaginativeness	.098	.922

Extraction Method: Maximum Likelihood.
Rotation Method: Varimax with Kaiser Normalization.[a]
a. Rotation converged in 3 iterations.

Rotated Factor Matrix[a]

	Factor	
	1	2
Entrepreneurial Competencies: Creative Problem Solving/Imaginativeness	.098	.922
Entrepreneurial Competencies: Building and Using Networks	.278	.692
Entrepreneurial Competencies: Self-Efficacy	.569	.666
Entrepreneurial Competencies: Value Creation	.404	.666
Entrepreneurial Competencies: Tenacity/Perseverance	.525	.665
Entrepreneurial Competencies: Opportunity Assessment	.539	.554
Entrepreneurial Competencies: Opportunity Recognition	.400	.527
Entrepreneurial Competencies: Conveying a Compelling Vision	.685	.420
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Entrepreneurial Competencies: Guerrilla Skills	.845	.165

Extraction Method: Maximum Likelihood.
Rotation Method: Varimax with Kaiser Normalization.[a]
a. Rotation converged in 3 iterations.

In analysing the extracted factors, two themes emerged regarding the entrepreneurial competencies the engineering administrator respondents felt was necessary for engineers to possess. The first theme related to the competencies engineering students need **to be** entrepreneurial. In this context, it was recognised that entrepreneurially oriented engineering students needed to be flexible, adaptable, strategic, proactive, opportunistic, and at the same time, have belief in themselves and their abilities. The second theme that emerged related to the competencies engineering students needed **to act** in an entrepreneurial capacity. These included the ability to, for example, employ creative problem solving, build and use networks, create value, and identify and take advantage of opportunities, all while being confident about the approaches taken and continuously moving forward when faced with adversity. The emergence of these two themes resulted in the identification of two groups of competencies that the engineering school administrator respondents felt were required by engineering students. This is presented in Table 10.

Table 10: The competencies required for engineering undergraduates to be identified as entrepreneurial

The competencies required for engineering undergraduates to be identified as entrepreneurial	
The competencies required for engineering students *to be* entrepreneurial (*Theme One*)	**The competencies required for engineering students *to act* in an entrepreneurial capacity (*Theme Two*)**
Guerrilla Skills	Creative Problem Solving or Imaginativeness
Maintain Focus yet Adapt	Building and Using Networks
Resilience	*Self-Efficacy**
Resource Leveraging	Value Creation
Conveying a Compelling Vision	*Tenacity or Perseverance**
*Self-Efficacy**	*Opportunity Assessment**
*Opportunity Assessment**	Opportunity Recognition
*Tenacity or Perseverance**	

As shown in Table 11, 8 competencies were necessary for engineering students **to be** entrepreneurial, while 7 competencies were necessary for engineering students **to act** entrepreneurially. The table also shows that three competencies – *Self-Efficacy*, *Opportunity Assessment*, and *Tenacity* – were identified in both themes. From this, it can be seen that possession of these three competencies are considered important in an Entrepreneurial Engineering context.

The results of the factor analysis also made suggestions regarding the value placed on opportunity. Opportunity is the cornerstone of entrepreneurship – entrepreneurship is about identifying and taking advantage of opportunities (Shane & Venkataraman 2000). The findings revealed that only *Opportunity Assessment* was perceived as necessary for engineering students to be entrepreneurial, while both *Opportunity Recognition* and *Opportunity Assessment* were competencies perceived as necessary for engineering students to act entrepreneurially. The breakdown of the factor analysis data further showed relatively low factor loadings for these two competencies in comparison to other competencies.

5.6: The objectives of entrepreneurship initiatives for engineering undergraduates

As explained in section 3.5.1, entrepreneurship educational programmes had specific objectives which relate to the benefits that students can potentially gain from participation in these programmes. To determine the objectives of entrepreneurship educational programmes, the online questionnaire asked engineering school administrators to state the objectives of their entrepreneurship initiatives for engineering undergraduates at their institutions. Forty-Five engineering school administrators responded to this question and the analysis of their data revealed that entrepreneurship initiatives for engineering undergraduates had four specific objectives, which could be divided into two of the objectives of entrepreneurship education discussed in 3.5.1 – educating "about" and "for" entrepreneurship:

- To understand entrepreneurship (*educating "about" entrepreneurship*);
- To develop the entrepreneurial mindset (*educating "about" entrepreneurship*);
- To provide the skills needed to be entrepreneurial and act entrepreneurially (*educating "for" entrepreneurship*); and
- To provide practical entrepreneurial experience (*educating "for" entrepreneurship*).

First, entrepreneurship initiatives prepared students to understand entrepreneurship. This objective involved engineering undergraduates acquiring knowledge of entrepreneurial theories and concepts, as well as learning about what entrepreneurship is and what it entails. Second, entrepreneurship initiatives focused on the development of the entrepreneurial mindset, where the emphasis was on encouraging and enabling engineering undergraduates to appreciate entrepreneurship, awakening their entrepreneurial attitudes and desires, and stimulating engineering undergraduates' entrepreneurial mindsets. Having an entrepreneurial mindset, as described in section 2.3.1, is having a mindset that is growth-oriented (as opposed to fixed) (Reid & Ferguson 2011) which enables student to seek and pursue new opportunities, pursue the very best opportunities, execute and act on opportunities, and engage the energies of all people in their networks (McGrath & MacMillan 2000). Third, entrepreneurship initiatives provided the skills necessary for engineering students to be entrepreneurial and act entrepreneurially. This objective is associated with the desire for engineering undergraduates to become innovators and entrepreneurs by arming students with both entrepreneurial and intrapreneurial characteristics. In this case, the focus was on the provision of activities that enabled the development of the competencies needed for entrepreneurial behaviour to occur such as Opportunity Recognition and Assessment, Value Creation, Creative Problem Solving, and Perseverance (Morris et al. 2013b). Finally, entrepreneurship initiatives provided students with practical entrepreneurial experiences. The focus of this objective is on helping students to bring their ideas to fruition by fostering innovation and stimulating creativity. Under this objective, engineering undergraduates were taught to, for example, commercialise new technologies, develop new products, create and develop business plans, launch ventures and start-ups, and operate within the industry by stimulating the professional growth of students in order to enable them to work in small and large companies.

Overall, the findings showed that the entrepreneurship initiatives of the respondents' institutions did not possess a single objective, and instead differed in terms of their objectives. The findings further showed that these entrepreneurship initiatives educated engineering students "about" and "for" entrepreneurship, which are the two most common objectives of entrepreneurship education, as discussed in 3.5.1. As a result, entrepreneurship initiatives for engineering undergraduates can be grouped according to the objectives they possess.

5.7: The types of educational programmes used to educate engineering undergraduates about entrepreneurship

The descriptions of initiatives available on the institutions' websites were reviewed to determine the types of educational programmes used to educate engineering undergraduates about entrepreneurship. These initiative descriptions were then grouped according to their similarities, and the programme types were then identified.

The analysis of data revealed that there were five types of educational programmes used to educate engineering undergraduates about entrepreneurship. First, institutions offered *entrepreneurship-based bachelor degree programmes*, which are undergraduate degrees that combine engineering and entrepreneurship either within a single engineering degree or in dual degree options where students acquire two bachelor degree qualifications simultaneously: one in engineering and one in either entrepreneurship or in business with a major in entrepreneurship. Second, institutions offered s*hort entrepreneurship programs*, which engineering undergraduates could take alongside their engineering degrees. These included academic programs such as minors and certificates, or specialised entrepreneurship programs focused on specific aspects of entrepreneurship, where students could, for example, live and/or learn in entrepreneurial communities, take courses, and do practical hands-on entrepreneurial activities. Third, institutions offered e*ntrepreneurship experiential* or *practical learning programmes,* where students learned about entrepreneurship through hands-on entrepreneurial activities in lieu of academic courses. Fourth, institutions offered *individual entrepreneurship courses*, which were courses in entrepreneurship, innovation, product design and development, and other entrepreneurship-related areas that satisfied either compulsory or elective requirements of engineering degrees. Students could either add these courses to their single engineering degrees or undertake dual degrees that combined both engineering and business. Finally, institutions offered *individual entrepreneurial engineering courses and projects*, which were academic or experiential engineering courses that integrated entrepreneurship content. Like individual entrepreneurship courses, these courses satisfied either compulsory or elective requirements of engineering degrees. Table 11 shows the prevalence of each educational programme types offered by institutions in each of the five countries.

Table 11: The types of entrepreneurship educational programmes offered by tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States

The entrepreneurship educational programmes used to educate engineering undergraduates in Australia, Canada, New Zealand, the United Kingdom, and the United States. [N = 410]					
Entrepreneurship educational programme type	**Country**				
	Australia	**Canada**	**New Zealand**	**The United Kingdom**	**The United States**
Entrepreneurship-based bachelor degree programmes	32%	9%	83%	9%	3%
Short entrepreneurship programmes	21%	42%	0%	0%	70%
Entrepreneurship experiential or practical learning programmes	0%	9%	0%	0%	10%
Individual entrepreneurship courses	37%	31%	17%	82%	12%
Individual entrepreneurial engineering courses and projects	10%	9%	0%	9%	5%
Total number of initiatives	**19**	**33**	**6**	**44**	**308**

As shown in Table 12, the five types were used in institutions in Canada and the United States. Four of the five types were present in Australian institutions, three were present in the U.K. institutions, and two were present in New Zealand institutions. The findings also showed that *Individual entrepreneurship courses* was the primary type most commonly used in both Australian and U.K. institutions. On the other hand, s*hort entrepreneurship programmes* were the most prevalent type used by institutions in both Canada and the United States. The primary type used by New Zealand institutions was *entrepreneurship-based bachelor degree programmes*. Overall, the findings showed that institutions in the five countries used a variety of educational programme types to educate their engineering undergraduates about entrepreneurship.

5.8: The practical experiences in entrepreneurship initiatives for engineering undergraduates

Tertiary-level academic institutions offer opportunities for engineering students to gain hands-on experience in entrepreneurship through practical activities. These practical activities were of two types: co-curricular activities – for-credit practical entrepreneurship activities that were incorporated into the academic course curriculum – and extra-curricular activities – not-for-credit practical entrepreneurship activities that students could take external to their degrees. To determine the types of practical activities offered to engineering undergraduates, the descriptions of the entrepreneurship initiatives on the institutions' webpages were reviewed and the information about the practical activities offered was obtained and categorised.

The findings showed that in addition to the entrepreneurship educational programmes, the institutions offered a number of opportunities for their students to gain hands-on entrepreneurial experience. There were two primary types offered: "Business Creation" and "New Technology Creation" or "New Product Creation" activities. The first type offered was "Business Creation" activities, which were focused on the creation and launch of small business ventures or enterprises. These activities included, for example, the determination and assessment of business opportunities, development of business ideas, feasibility studies, the creation of business and marketing plans, elevator pitches of new business ideas, and eventually the design, development and launch of new enterprises and ventures. The second type offered was "New Technology Creation" or "New Product Creation" activities, which are activities related to the creation of products or technologies in new, innovative ways for previously undetermined purposes. These activities included, for example, the identification of customer or societal needs, generation of technical solutions, the development of ideas for new technologies/products, the design of these technologies/products, the creation and development of business plans for these new technologies/products, the development and creation of prototypes, patent and commercialisation issues, the pitch of these new technologies/products to potential investors, and the eventual launch of these new technologies/products into the market. These two primary types of practical entrepreneurial experience were offered by the majority of institutions in all five of the countries, as shown in Table 12.

Table 12: The primary co- and extra-curricular entrepreneurial activities offered by tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States

The primary co- and extra-curricular entrepreneurial activities for engineering undergraduates in Australia, Canada, New Zealand, the United Kingdom, and the United States. [N = 335]					
The primary co- and extra-curricular activity types	**Country**				
	Australia	**Canada**	**New Zealand**	**The United Kingdom**	**The United States**
Total number of entrepreneurship initiatives for engineering undergraduates	19	33	6	44	308
Percentage of initiatives offering "Business Creation" Activities	69%	46%	60%	62.5%	46%
Percentage of initiatives offering "New Technology Creation"/"New Product Creation" Activities	12%	43%	40%	25%	23%
Percentage of initiatives offering both "Business Creation" Activities & "New Technology Creation"/"New Product Creation" Activities	19%	11%	0%	12.5%	31%
Total number of initiatives offering "Business Creation" Activities and/or "New Technology Creation"/"New Product Creation" Activities	**16**	**28**	**5**	**24**	**262**

As shown in Table 12, "Business Creation" activities were the most common type of practical activities offered to engineering undergraduates. There was a great disparity between initiatives that offered "Business Creation" activities and those that offered "New Technology Creation" activities or "New Product Creation" activities. The only exception was the Canadian institutions, where initiatives that offered "Business Creation" activities and initiatives that offered “New Technology Creation” activities or “New Product Creation” activities were almost equally prevalent. In addition, the findings also revealed that there were initiatives present in Australian, Canadian, U.K., and U.S. institutions which offered both “Business Creation” activities and “New Technology Creation” activities/“New Product Creation” activities.

Overall, the findings illustrate that entrepreneurship initiatives for engineering undergraduates provided opportunities for students to primarily gain experience in either business creation or in the development of new technologies or products. Despite this, the majority of initiatives examined largely provided opportunities for students to gain experience in the creation of new businesses.

5.9: The opportunities offered in entrepreneurship initiatives for engineering undergraduates

Entrepreneurship initiatives for engineering undergraduates offer a number of opportunities that facilitate, support, and enhance entrepreneurial development. To determine which opportunities were offered to engineering undergraduates, the online questionnaire sent to engineering school administrators provided the following ten opportunities:

- Take an entrepreneurship course within the Faculty/School of Engineering;
- Intern or work for an entrepreneurial or start-up company;
- Conduct market research and analysis for a new product or technology;
- Develop a product or technology for a real client/customer;
- Give an “elevator pitch” or presentation to a panel of judges about a product or business idea;
- Be involved in patenting a technology or protecting intellectual property;
- Be involved in entrepreneurship- or business-related student organisations;
- Write a business plan;
- Participate in an entrepreneurship-related competition (e.g. product development, business plan);
- Participate in entrepreneurship-related workshops (extra-curricular, non-credit).

Administrators were then asked to select all the opportunities that they offered. The questionnaire also provided a text box where administrators could state any additional opportunities that they offered.

The findings first revealed that all ten opportunities were offered in the respondents' entrepreneurship initiatives. No additional opportunities were provided by the respondent administrators. Table 13 shows the opportunities offered in entrepreneurship initiatives for engineering undergraduates.

Table 13: The opportunities offered in entrepreneurship initiatives for engineering undergraduates

The opportunities offered in entrepreneurship initiatives for engineering undergraduates [N = 71]	
The opportunities	**Percentage (%) of respondents offering the opportunities**
Develop a product or technology for a real client/customer	70%
Participate in an entrepreneurship-related competition	69%
Take an entrepreneurship course within the Faculty/School of Engineering	68%
Give an "elevator pitch" or presentation to a panel of judges about a product or business idea	68%
Be involved in entrepreneurship- or business-related student organisations	68%
Write a business plan	66%
Intern or work for an entrepreneurial or start-up company	63%
Participate in entrepreneurship-related workshops	63%
Conduct market research and analysis for a new product or technology	54%
Be involved in patenting a technology or protecting intellectual property	54%

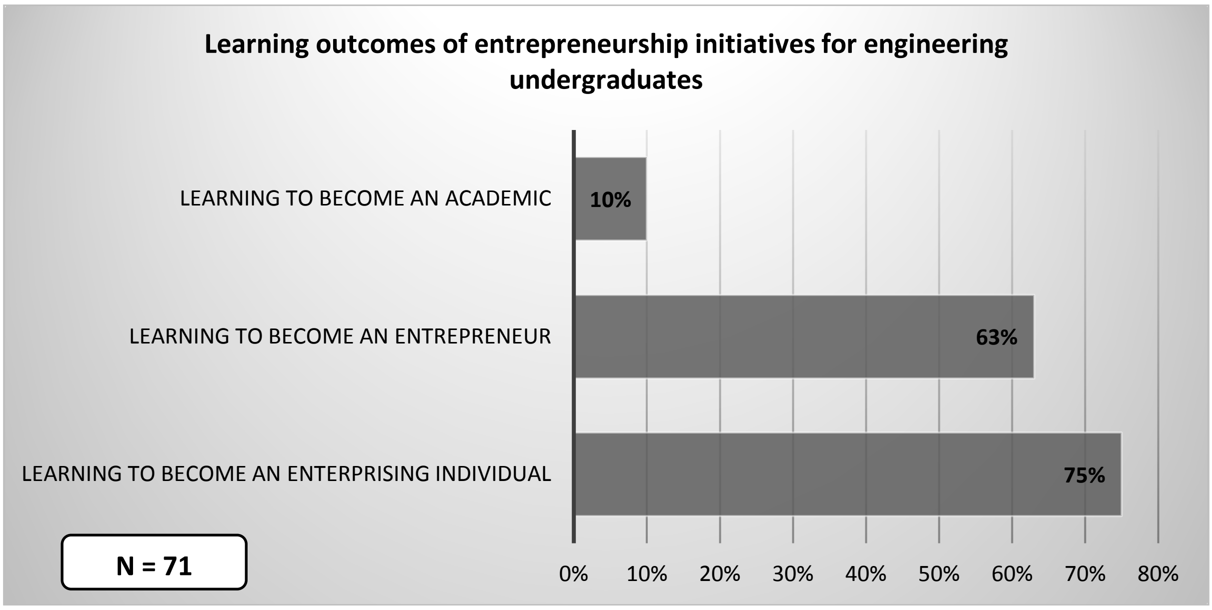
*opportunities are listed from the opportunity that has been offered by the greatest number of respondents to the opportunity that has been offered by the least number of respondents

As presented in Table 13, the majority of the respondents' institutions offered opportunities for their engineering undergraduates to develop a product or technology for a real client or customer. Simultaneously, the findings showed that two opportunities were offered by the smallest percentage of the respondents: the opportunity to conduct market research and analysis for a new product or technology, and the opportunity to be involved in patenting a technology or protecting intellectual property. The findings also showed that the entrepreneurship initiatives for engineering undergraduates offered by the institutions surveyed focus primarily on the creation of new products and technologies as opposed to the background, research work on the product or technology or the work necessary to bring the product or technology to market.

5.10: The outcomes of entrepreneurship initiatives for engineering undergraduates

The design and structure of educational programs are dependent on the intended outcomes – i.e. what institutions want their students to learn (Fayolle & Gailly 2008). To determine the outcomes of entrepreneurship initiatives for engineering undergraduates, the online questionnaire asked engineering school administrators to state whether their entrepreneurship initiatives for engineering undergraduates were designed to educate students to become enterprising individuals, entrepreneurs, or academics. The questionnaire also allowed administrators to identify whether their entrepreneurship initiatives had multiple outcomes. The findings are presented in Figure 26.

Figure 26: The outcomes of entrepreneurship initiatives for engineering undergraduates



As presented in Figure 26, the primary outcome of entrepreneurship initiatives offered by institutions surveyed was for students to become enterprising individuals; where students acquire entrepreneurial mindsets, develop entrepreneurial personas, and then act in entrepreneurial ways. This revelation was in line with the entrepreneurial competencies identified as being required by engineering students in section 5.5.

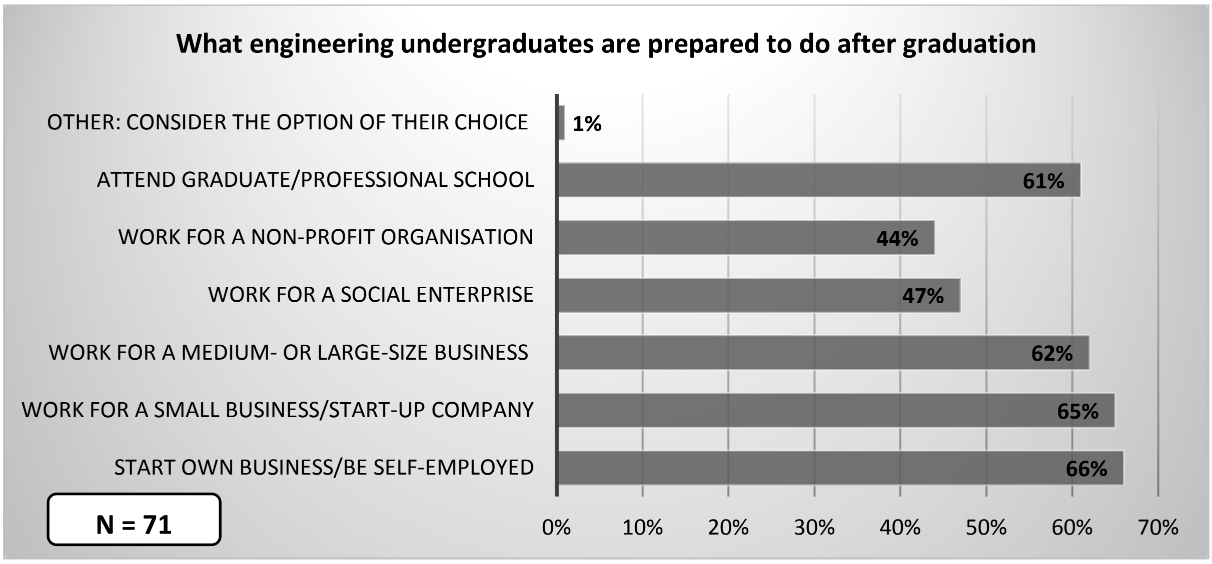
On completion of participation in entrepreneurship initiatives, engineering undergraduates must be prepared to not only take on traditional engineering roles, but also combine entrepreneurial abilities in order to act in entrepreneurial manners and contribute to entrepreneurial economies (Weaver & Rayess 2010). To determine the entrepreneurial roles students were prepared to take on, the online questionnaire asked engineering administrators to identify what their students were encouraged to do after graduation. The following six choices were provided:

- Start their own business or be self-employed;
- Work for a small business or start-up company;
- Work for a medium- or large-size business;
- Work for a social enterprise;
- Work for a non-profit organisation;
- Attend graduate/professional school.

The respondents were asked to select all the choices that applied to their initiatives, and any additional choices their students were encouraged to pursue.

The findings revealed that once engineering undergraduates had participated in the entrepreneurship initiatives of the institutions surveyed, they were prepared to undertake the six choices provided in the questionnaire. The prevalence of these choices within these entrepreneurship initiatives and the identification of what the students were prepared to do are presented in Figure 27.

Figure 27: What engineering undergraduates are prepared to do after participation in entrepreneurship initiatives



As shown in Figure 27, the majority of respondents stated that their institutions prepared their students to start their own business or be self-employed, with working for small, medium and large businesses and attending graduate school also being stated by more than 60% of respondents. Only one engineering school administrator provided an ‘Other’ response stating that students who participated in the initiative were encouraged to consider a future option of their choice. The revelation that students were primarily prepared to start their own business or be self-employed was interesting, particularly given that the primary outcome of the entrepreneurship initiatives examined was for students to become enterprising individuals and not necessarily entrepreneurs, as seen in Figure 26. Another interesting finding was the high percentage of respondents who stated that their students were prepared to further their education by attending graduate or professional school, in comparison to the small percentage of respondents who identified becoming an academic as an outcome of their entrepreneurship initiatives for engineering undergraduates. A third interesting finding was that less than 50% of respondents stated that their engineering students were prepared to work for social enterprises or non-profit organisations. This shows that in the entrepreneurship initiatives from the institutions surveyed, less value was placed on doing work in areas where profit generation was ultimately not the main goal of the enterprise or organisation.

In summary, the primary desired outcome of the initiatives in this study was for students to become enterprising individuals, with a high percentage of the initiatives also educating their students to become entrepreneurs. In addition, the majority of the initiatives from the institutions surveyed prepared their students to start their own businesses, with the preparation of students to work in small, medium, and large-sized businesses or to attend graduate or professional school being almost equally prevalent. Overall, the findings revealed that the entrepreneurship initiatives from the institutions surveyed had one or more of three outcomes, with students being educated to either become enterprising individuals, entrepreneurs, or academics. The findings also revealed that these entrepreneurship initiatives all prepared their students to move into six different career directions where they were able to use their entrepreneurial capabilities.

5.11: Chapter Summary

This chapter reported the different findings related to entrepreneurship education for engineering students. First, the chapter explained the prevalence of entrepreneurship education for engineering undergraduates based on the activities offered by tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States. Next, there was a discussion of the support provided by these academic institutions in these five countries for the development of entrepreneurship education; and an explanation of how entrepreneurship education had been integrated into the undergraduate engineering curriculum. The chapter then continued with discussions of the entrepreneurial competencies required by engineering undergraduates, the objectives of entrepreneurship initiatives for engineering undergraduates, the types of educational programmes used to educate engineering undergraduates about entrepreneurship, and the types of practical experiences and opportunities offered in entrepreneurship initiatives for engineering undergraduates. The chapter concludes with a discussion of the outcomes of entrepreneurship initiatives for engineering undergraduates.

Chapter Six presents the research findings about the models used by tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States to educate engineering undergraduates about entrepreneurship.

Chapter 6: Research Findings Part II

6.1: Introduction

Chapter Six presents a description of the typology of models identified in this research, which shows how the tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States educate engineering undergraduates about entrepreneurship. The chapter begins with an identification of the models that the typology is comprised of. Next, it provides details about the models present in each of the five countries. The chapter concludes with presenting the components of each of these models.

6.2: The Entrepreneurial Engineering Education (EEE) Typology of models for educating engineering undergraduates about entrepreneurship

The Standish-Kuon and Rice (2002) typology, as explained in section 3.7, was developed to show how engineering students at U.S. institutions were educated about entrepreneurship. The models of this typology were distinguished by the schools responsible for the creation and development of the initiatives, and the home base of the initiative, or where the initiative was housed. To further show the differences amongst the models, Standish-Kuon and Rice (2002) also looked at the curriculum used and the schools responsible for the curriculum's development, the students the initiatives were designed to target, the schools within which the entrepreneurship courses were taught, and the faculty that taught the entrepreneurship courses. In this research, these characteristics were used to determine the models presently being used to educate engineering undergraduates not only in the United States, but also in Australia, Canada, New Zealand, and the United Kingdom. This section describes the typology that emerged, including the models identified and the models used in each of the five countries. The typology developed here was named the Entrepreneurial Engineering Education, or EEE, Typology.

6.2.1: The EEE Typology

To determine the models presently used by academic institutions to educate engineering undergraduates about entrepreneurship, the main distinguishing characteristics from the Standish-Kuon and Rice (2002) study, presented in Table 14, were used to categorise the entrepreneurship initiatives according to the Standish-Kuon and Rice (2002) models.

Table 14: The characteristics used to distinguish among the models identified in the Standish-Kuon and Rice (2002) study

The distinguishing characteristics of the Standish-Kuon and Rice (2002) study		
Model	**The schools responsible for the creation and development of the entrepreneurship initiative**	**The schools where the initiative was housed (i.e. the home base of the entrepreneurship initiative)**
The *Business School* model	The business school	The business school
The *Engineering School* model	The engineering and business schools	The engineering school
The *Multi-School* model	The business school, the engineering school, and one or more technical schools	Either the business school or the engineering school

Webpage descriptions of the entrepreneurship initiatives were reviewed to identify which schools were responsible for the development of the initiatives and within which school the initiatives were housed. Once this information was collected, the initiatives that either exactly or closely resembled the distinguishing characteristics used in the Standish-Kuon and Rice (2002) study were categorised as either *Business School*, *Engineering School*, and *Multi-School* model initiatives. The initiatives that did not meet the criteria outlined in the Standish-Kuon and Rice (2002) study were further separated and grouped according to their similarities, which ultimately resulted in the creation of additional models.

Like the Standish-Kuon and Rice (2002) study, evidence was found to confirm the presence of the *Business School*, *Engineering School*, and *Multi-School* models. In comparison to the Standish-Kuon and Rice (2002) study, however, differences were found in the distinguishing characteristics of the three models. From the Standish-Kuon and Rice (2002) study, it was inferred that the business school acted in isolation without involvement from other schools. In contrast, the findings from this study showed the presence of entrepreneurship initiatives created solely by the business schools, and initiatives developed by the business school in collaboration with another of the institutions' schools, primarily the engineering school. The findings also revealed that the *Business School* model initiatives, as identified in the Standish-Kuon and Rice (2002) study, were housed in the business school.

For the *Engineering School* model, the findings revealed that there were entrepreneurship initiatives created by the engineering school in collaboration with the business school, as identified in the Standish-Kuon and Rice (2002) study. However, the findings also revealed the presence of *Engineering School* model entrepreneurship initiatives created solely by the engineering school. Like the Standish-Kuon and Rice (2002) study, the initiatives were identified as being housed in the engineering school. Conversely, the findings also showed that there were *Engineering School* model initiatives housed in other locations – the business school, both the engineering school and an innovation centre, freestanding entrepreneurship schools, and, in the case of engineering-only institutions, in all departments of an institution.

Standish-Kuon and Rice (2002) classified *Multi-School* model entrepreneurship initiatives as those developed by the business school, the engineering school, and one or more science or technical schools. Although this study identified initiatives developed by the engineering, business, and science/technical schools, it also found that there were *Multi-School* model partnerships involving the business and engineering schools and other schools at the institution. These schools included, for example, Schools of Arts, Law, and Journalism. There was one exception, where the partnership included multiple schools but excluded the business school. Standish-Kuon and Rice (2002) also determined that *Multi-School* model entrepreneurship initiatives were housed either in the business school or engineering school. The findings revealed that *Multi-School* model initiatives were primarily housed in the business school, with some initiatives housed in the engineering school. However other home base locations were identified, including the School of Arts & Sciences and freestanding entrepreneurship schools. Some initiatives were housed in both the engineering school and other locations such as the Schools of Arts and Sciences, Visual and

Performing Arts, or Business. The data analysis also showed that there were *Multi-School* model entrepreneurship initiatives situated in each of the member schools of the partnership.

The analysis of the remaining initiatives that did not fit the distinguishing characteristics of the *Business School*, *Engineering School*, and *Multi-School* model entrepreneurship initiatives were categorised into two groups, which resulted in two additional models. The first of these two models, which was named the *External Partnership* model, was similar to the *Engineering School* model, but involved a collaborative effort between the home institution and external partners. These collaborations involved the engineering school of the academic institution and either external networks that supported the development of entrepreneurship education, local organisations that contributed resources to entrepreneurship initiatives, or other tertiary-level academic institutions. In addition, some partnerships also involved the business school of the home institution. The engineering school was the primary home base of *External Partnership* model entrepreneurship initiatives; however some initiatives were housed in either the business school, or both the engineering and business schools.

The second model, which was entitled the *Institution* model, contained entrepreneurship initiatives derived from the institutions' efforts to educate the entire student population about entrepreneurship, regardless of the degree and major being pursued. These initiatives were generally developed by freestanding entrepreneurship schools, or the collective actions of the schools of an institution. The findings also revealed that *Institution* model entrepreneurship initiatives were primarily housed in freestanding entrepreneurship schools, but also in other locations including the business school, the engineering school, both the business and engineering schools, another of the institutions' schools, or in both freestanding entrepreneurship schools and an additional school, such as the business or engineering schools.

These combination of the five models resulted in the creation of the Entrepreneurial Engineering Education (EEE) Typology, summarised in Table 15.

Table 15: The Entrepreneurial Engineering Education (EEE) typology of models used to educate engineering students about entrepreneurship

The Entrepreneurial Engineering Education (EEE) typology of models used to educate engineering undergraduates about entrepreneurship		
Model	**Model name**	**Distinguishing Characteristic of Model**
Model 1	The *Business School* model	*Entrepreneurship initiatives developed either solely by the business school or by the business school in collaboration with another school–primarily the engineering school–with the initiatives housed in the business school*
Model 2	The *Engineering School* model	*Entrepreneurship initiatives developed either solely by the engineering school, or by the engineering school in collaboration with the business school, with the initiatives primarily housed in the engineering school*
Model 3	The *Multi-School* model	*Entrepreneurship initiatives resulting from a partnership involving the engineering school, the business school, and one or more of the other schools at the academic institution, with some partnerships excluding the business school*
Model 4	The *External Partnership* model	*Entrepreneurship initiatives developed from a partnership involving either the engineering school or both the engineering and business schools of an institution and external organisations or other tertiary-level academic institutions*
Model 5	The *Institution* model	*Entrepreneurship initiatives developed by academic institutions to educate all students at an academic institution, regardless of major, about entrepreneurship*

The following sections will examine the use of the five models within the EEE typology by educational institutions within the different countries included in this research study.

6.2.2: The models used by tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States to educate engineering undergraduates about entrepreneurship

The findings showed that the use of the five models of the EEE typology differed across the five countries. This is shown in Table 16.

Table 16: The models used by tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States to educate engineering undergraduates about entrepreneurship

The models used to educate engineering undergraduates about entrepreneurship in Australia, Canada, New Zealand, the United Kingdom, and the United States. ***(√ - yes; × - no)***						
Country	***Business School* model**	***Engineering School* model**	***Multi-School* model**	***External Partnership* model**	***Institution* model**	**Total number of models**
Australia	√	√	×	×	√	3
Canada	√	√	×	√	×	3
New Zealand	√	√	×	×	×	2
The United Kingdom	×	√	×	×	√	2
The United States	√	√	√	√	√	5

As shown in Table 16, the *Engineering School* model was the only model used in all of the five countries. This is a significant finding given that research undertaken by Shartrand et al. (2010) indicated entrepreneurship education programmes for engineering undergraduates were unlikely to be housed in engineering schools. The *Business School* model was present in all the countries, except the United Kingdom. The *Institution* model was used in Australia, the United Kingdom, and the United States, while the *External Partnership* model was used in Canada and the United States. The *Multi-School* model was not present in any other country outside the United States. The models used in each country will be discussed in the following sub-sections.

6.2.2.1: The models used in Australia

In Australia, 36 tertiary-level academic institutions had undergraduate engineering programmes accredited by Engineers Australia. Of these 36, 13 institutions offered opportunities for engineering undergraduates to be educated about entrepreneurship. Of the five models described in section 5.3.1, three were used in Australia, as presented in Table 17: the *Engineering School*, the *Business School*, and the *Institution* models.

Table 17: The models used by Australian tertiary-level academic institutions to educate engineering undergraduates about entrepreneurship

The models used by Australian tertiary-level academic institutions to educate engineering undergraduates about entrepreneurship *(N = 13)*		
Model	**Number of institutions following the model**	**Percentage (%) of institutions following the model**
Business School	3	23%
Engineering School	10	77%
Institution	2	15%

In Australia, the *Engineering School* model was used by the majority of the institutions. The findings revealed that 8 of the 13 institutions offered single initiatives, thereby following one model. Furthermore, 3 institutions offered multiple initiatives all under the same model, and 2 institutions offered multiple initiatives and therefore followed multiple models.

6.2.2.2: The models used in Canada

In Canada, 42 institutions had undergraduate engineering programmes accredited by Engineers Canada, with 24 providing entrepreneurship initiatives for engineering undergraduates. Like Australia, 3 of the 5 models were used amongst the 24 institutions: the *Business School*, the *Engineering School*, and the *External Partnership* models, details of which are in Table 18.

Table 18: The models used by Canadian tertiary-level academic institutions to educate engineering undergraduates about entrepreneurship

The models used by Canadian tertiary-level academic institutions to educate engineering undergraduates about entrepreneurship *(N = 24)*		
Model	**Number of institutions following the model**	**Percentage (%) of institutions following the model**
Business School	11	46%
Engineering School	16	67%
External Partnership	1	4%

In Canada, the *Engineering School* model was used by the majority of the institutions. Of the 24 Canadian institutions, 18 offered single entrepreneurship initiatives, which meant that each institution followed a single model, 3 institutions offered multiple initiatives under a single model, and 4 institutions offered multiple initiatives and followed two models.

6.2.2.3: The models used in New Zealand

In comparison to the other four countries, New Zealand had the fewest number of institutions with accredited undergraduate engineering programmes. A total of 8 institutions had undergraduate engineering programmes accredited by the Institution of Professional Engineers New Zealand (IPENZ). Of these 8 institutions, 5 offered opportunities for engineering undergraduates to learn about entrepreneurship, as presented in Table 19.

Table 19: The models used by New Zealand tertiary-level academic institutions to educate engineering undergraduates about entrepreneurship

The models used by New Zealand tertiary-level academic institutions to educate engineering undergraduates about entrepreneurship *(N = 5)*		
Model	**Number of institutions following the model**	**Percentage (%) of institutions following the model**
Business School	1	20%
Engineering School	4	80%

In New Zealand, the *Business School* model and the *Engineering School* model were the two models used. The findings showed that the *Engineering School* model was the primary model used. Furthermore, only 1 of the 5 institutions – which used the *Engineering School* model – offered multiple initiatives, both under the same model. The findings also revealed that, unlike the Australian and Canadian institutions, none of the New Zealand institutions used multiple models.

6.2.2.4: The models used in the United Kingdom

A total of 100 U.K. tertiary-level academic institutions offered undergraduate engineering programmes accredited by the Engineering Council U.K. The research findings showed that only two models were used in the United Kingdom, as presented in Table 20.

Table 20: The models used by U.K. tertiary-level academic institutions to educate engineering undergraduates about entrepreneurship

The models used by U.K. tertiary-level academic institutions to educate engineering undergraduates about entrepreneurship *(N = 36)*		
Model	**Number of institutions following the model**	**Percentage (%) of institutions following the model**
Engineering School	33	92%
Institution	3	8%

Both the *Engineering School* model and the *Institution* model were used in the United Kingdom. The *Engineering School* model was the model used by the majority of the institutions, and none of the 36 institutions used multiple models. However, 6 institutions, all of which used the *Engineering School* model, offered multiple initiatives under the same model.

6.2.2.5: The models used in the United States

The United States had a total of 414 tertiary-level academic institutions with undergraduate engineering programmes accredited by the Accreditation Board for Engineering and Technology, Inc. (ABET). A total of 203 institutions provided opportunities for their engineering undergraduates to learn about entrepreneurship. This country was the only one of the five where the five models were present, as showed in Table 21.

Table 21: The models used by U.S. tertiary-level academic institutions to educate engineering undergraduates about entrepreneurship

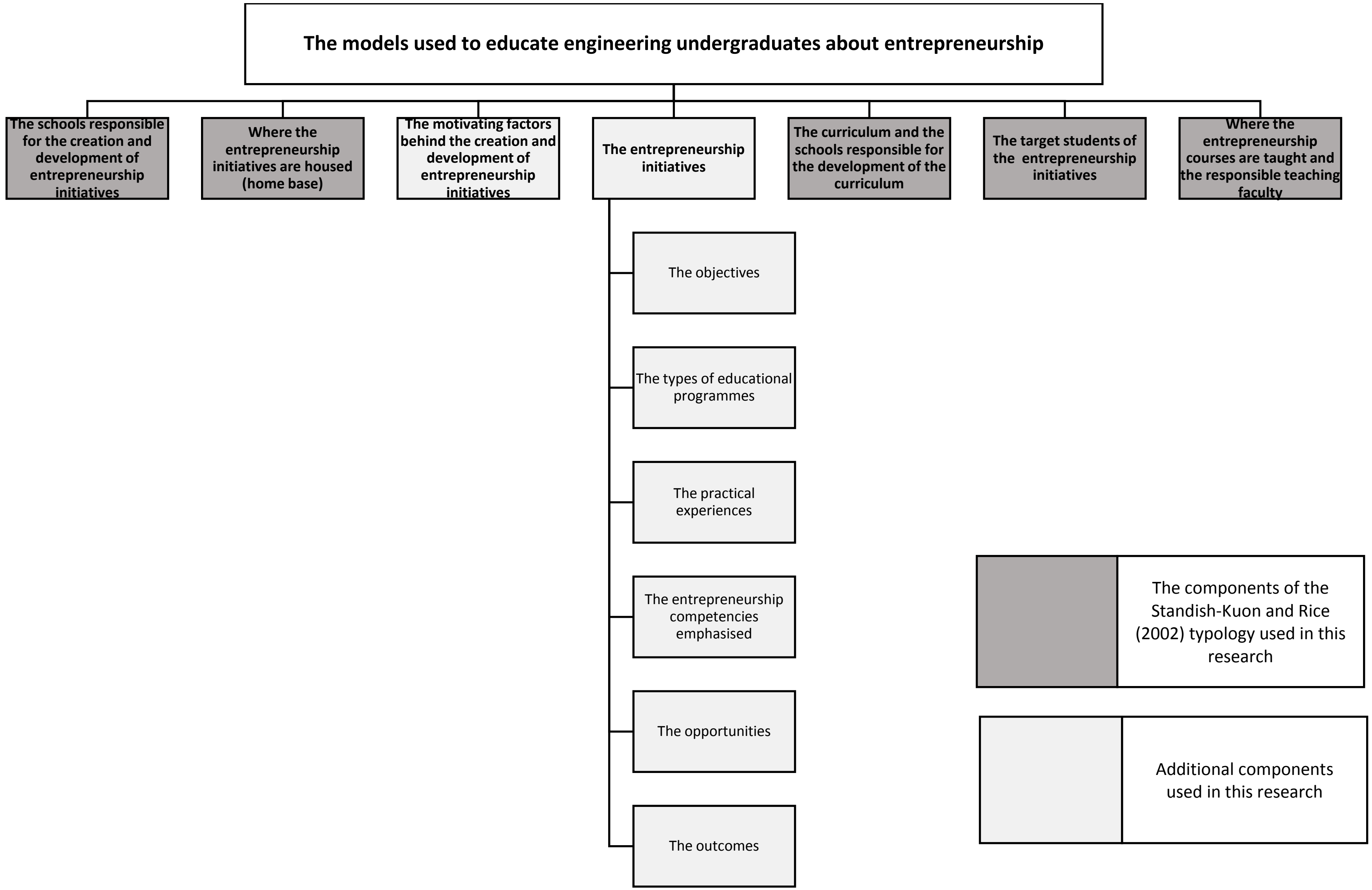
The models used by U.S. tertiary-level academic institutions to educate engineering undergraduates about entrepreneurship *(N = 203)*		
Model	**Number of institutions following the model**	**Percentage (%) of institutions following the model**
Business School	126	62%
Engineering School	61	30%
Multi-School	16	8%
External Partnership	25	12%
Institution	20	10%

In contrast to the previous four countries, the model used by the majority of the 203 institutions was the *Business School* model. Table 21 also shows that one of the original Standish-Kuon and Rice (2002) models, the *Multi-School* model, was the least used of the five models, with the model seen in less than 10% of the institutions reviewed. The findings also revealed that 38 of the institutions had multiple initiatives that all fell under the same model, and 42 of the institutions had multiple initiatives that were categorised under different models, with 39 of these 42 institutions following 2 models and the 3 remaining institutions following 3 models.

6.2.3: The components of the models of the EEE Typology

A number of different characteristics were used to produce descriptions of each of the models of the EEE typology, and compare these models against each other. The content of the models contains the five distinguishing characteristics used in the Standish-Kuon and Rice (2002) study: the schools responsible for the development of the initiatives, the location where the initiatives were housed, the curriculum and the schools that developed it, the target students, the location where the entrepreneurship courses were taught, and the faculty members responsible for the teaching of the entrepreneurship courses. Other data about the entrepreneurship initiatives for engineering undergraduates was then collected and analysed to further determine if additional differences. The description of each of the models was comprised of the content presented in Figure 28.

Figure 28: The components of the models used to educate engineering undergraduates about entrepreneurship



The following sections provide descriptions of each of the five models. The descriptions first focus on the distinguishing characteristics identified in the Standish-Kuon and Rice (2002) study, and then on the analysis of additional characteristics to determine if there were any other characteristics that could be used to distinguish among the models.

6.3: The EEE Typology Model 1: The *Business School* Model

The description of the *Business School* model is divided into 11 sections. The first 4 sections represent the groups of characteristics identified in the Standish-Kuon and Rice (2002) study, while the remaining 7 sections describe additional characteristics obtained in the research. In the first 4 sections, the description begins with a summary of the findings from the Standish-Kuon and Rice (2002) study, and then presents the findings from this study to highlight the existing comparisons. The full description of each model begins with the U.S.-based models and then continues with the comparable data from the model in each of the respective countries.

6.3.1: The schools responsible for the creation and development, and the home base, of *Business School* model entrepreneurship initiatives

Standish-Kuon and Rice (2002) identified a *Business School* model initiative as one developed by and housed within the business school. These characteristics were the factors that indicated whether an entrepreneurship initiative followed the *Business School* model. To determine whether these distinguishing characteristics were still applicable to the identification of a *Business School* model entrepreneurship initiative, descriptions of the entrepreneurship initiatives on the institutions' webpages were reviewed to collect data about where the initiatives were housed and the schools that were responsible.

The *Business School* model, as discussed in section 6.2.2, was used not only in the United States, but also in Australia, Canada, and New Zealand. The findings revealed that in the United States, *Business School* model entrepreneurship initiatives were primarily developed by the business school, as seen in 142, or approximately 95%, of the 150 U.S. *Business School* model initiatives. However, in contrast to the findings of the Standish-Kuon and Rice (2002) study, the remaining 8 initiatives were developed by the business school in collaboration with another school, with 7 initiatives developed by both the business and engineering schools, and the final initiative developed by the business and media schools.

Like the U.S. *Business School* model entrepreneurship initiatives, the *Business School* model initiatives in Australia and Canada were mainly developed by the business school. This was the case in 3 of the 4 initiatives in Australia and 12 of the 13 initiatives in Canada. The remaining Australian and Canadian initiatives were developed by the business and engineering schools. The single *Business School* model entrepreneurship initiative in New Zealand was developed solely by the business school.

Despite the differences that existed in the schools responsible for the creation and development of the entrepreneurship initiatives, the findings revealed that all of the *Business School* model entrepreneurship initiatives were housed in the business school.

6.3.2: The curriculum used in *Business School* model entrepreneurship initiatives

As identified in the Standish-Kuon and Rice (2002) study, *Business School* model initiatives used a technological entrepreneurship curriculum that was developed by the business school in collaboration with the engineering school. In reviewing the initiatives, three curriculum types were identified: a *business-focused* curriculum, which is centred on the creation and running of new business ventures or enterprises, a *technologically-focused* curriculum, which is focused on the creation of new technologies and products that meet the needs of customers and the society on a whole, and an *entrepreneurship-focused* curriculum, which is used to educate students about what entrepreneurship is, what it entails, and the relevant entrepreneurship theories and concepts. To determine the type of curriculum used in *Business School* model entrepreneurship initiatives, the descriptions of each of the curriculum types were taken and compared to the content in entrepreneurship programmes and individual course descriptions on the institutions' webpages.

In the United States, the *Business School* model initiatives used different curriculum types which were developed by the schools responsible for the creation and development of the initiatives. The findings revealed that the most prevalent type was a business-focused curriculum, with a business- and entrepreneurship-focused curriculum, a business- and technologically-focused curriculum, and a business-, technologically-, and entrepreneurship-focused curriculum also commonly seen. In addition, one initiative used a technologically-focused curriculum, while another used an entrepreneurship-focused curriculum.

The findings also revealed that multiple curriculum types were used outside of the United States. The Australian entrepreneurship initiatives used two curriculum types: a business- and entrepreneurship-focused curriculum, which was used in two of the four entrepreneurship initiatives; and a business-, technologically-, and entrepreneurship-focused curriculum, which was used in the remaining two entrepreneurship initiatives. The Canadian initiatives primarily used a business-focused curriculum, as seen in 6, or approximately 46%, of the 13 initiatives. Of the remaining seven initiatives, five used a business- and entrepreneurship-focused curriculum, and the final two used a business- and technologically-focused curriculum. The New Zealand *Business School* model initiative used a business- and entrepreneurship-focused curriculum.

Overall, the findings revealed that although there were curriculum types that were individually business-focused, technologically-focused, or entrepreneurship-focused, the *Business School* model initiatives also used combinations of two or three of the curriculum types. This showed that despite that fact that the initiatives all followed the Business School models they did not necessarily have the same focus.

6.3.3: Target students of *Business School* model entrepreneurship initiatives

The target students of the *Business School* model entrepreneurship initiatives identified in the Standish-Kuon and Rice (2002) study included business, engineering, and possibly other non-business students. To determine the target students of the *Business School* model entrepreneurship initiatives, initiative descriptions on the institutions' webpages were reviewed to identify which students the initiatives were offered to.

In contrast to the findings of the Standish-Kuon and Rice (2002) study, U.S *Business School* model initiatives in U.S. institutions were primarily designed for all undergraduate students regardless of the major followed, but also designed for non-business undergraduates, or specifically for engineering and business undergraduates. One initiative reviewed was designed specifically for engineering undergraduates, while another was designed for engineering undergraduates as well as undergraduates from some of the other schools at the institution, but excluded business school undergraduates.

Like U.S. *Business School* model entrepreneurship initiatives, Australian *Business School* model initiatives developed by the business school were designed primarily for all undergraduate students. For the entrepreneurship initiative developed by the business and engineering schools, the target group was both business and engineering undergraduates. Canadian *Business School* model initiatives, on the other hand, were primarily designed for non-business students, which was found in approximately 62% of the 13 entrepreneurship initiatives, but also commonly designed for all undergraduates. One initiative reviewed was designed for both engineering and business undergraduates, while another was designed specifically for engineering undergraduates. The New Zealand *Business School* model entrepreneurship was designed for all undergraduate students.

Overall, the findings showed that although *Business School* model entrepreneurship initiatives were designed for different groups of students, they were primarily designed for all undergraduate students. The findings from this research are in line with those of the Standish-Kuon and Rice (2002) study – they showed that *Business School* model entrepreneurship initiatives were mainly designed for engineering students to collaborate with students from other schools at the institution. This suggests that engineering undergraduates do not learn to be entrepreneurial by interacting only with other engineering undergraduates. Furthermore, it suggests that *Business School* model entrepreneurship initiatives were primarily designed to create an environment where engineering undergraduates can not only learn to become multidisciplinary in terms of their knowledge and skills, but also learn to operate in multidisciplinary settings and work alongside others from a variety of educational backgrounds.

6.3.4: The locations where the courses in *Business School* model entrepreneurship initiatives are taught and the faculty responsible for the teaching of entrepreneurship

The findings of the Standish-Kuon and Rice (2002) study revealed that the entrepreneurship courses of *Business School* model entrepreneurship initiatives were taught by business academics, either in the business or engineering schools. First, to determine the location of the entrepreneurship courses, course listings on the institutions' webpages were reviewed to see which schools they were offered in. Next, the pages of the faculty members who taught the courses were reviewed to learn about them, their job titles, and the schools within which they were based. In addition, the online questionnaire sent to engineering school administrators provided respondents with six groups and asked them to identify from the following groups which were responsible for teaching their entrepreneurship courses:

- Engineering Academics;
- Business Academics;
- Engineering Graduate Students;
- Business Graduate Students; and
- Practicing or Experienced Entrepreneurs.

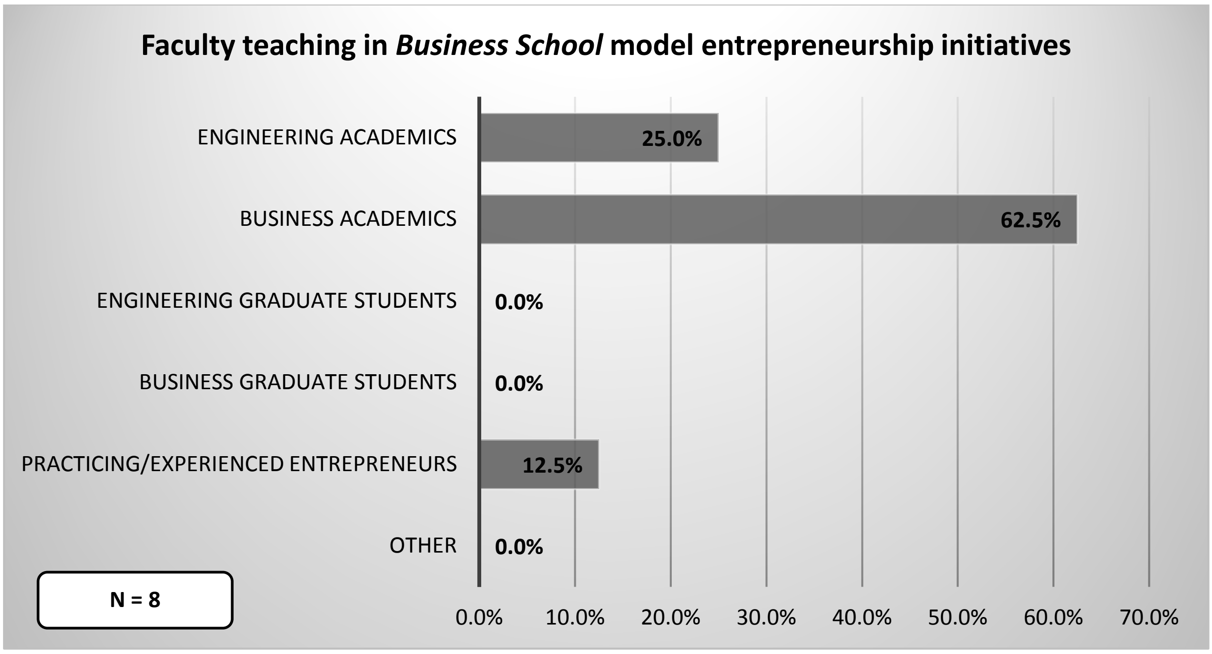
Respondents were also provided with the opportunity to identify any other groups that held teaching responsibilities.

The findings revealed that in the United States, the courses in *Business School* model initiatives were taught in more than one location. The courses were primarily taught in the business school, but in some initiatives, courses were taught in both the business and engineering schools. There were four exceptions. In one initiative, the courses were taught in a freestanding entrepreneurship school. In another, the courses were taught in both the business and media schools. In a third, the courses were taught in the schools of engineering, business, and arts and sciences. In the fourth, the courses were taught in the engineering school. In contrast to U.S. *Business School* model entrepreneurship initiatives, the findings revealed that the entrepreneurship courses in Australian, Canadian, and New Zealand *Business School* model initiatives were taught in the business school.

The findings further revealed the locations of the faculty that taught the entrepreneurship courses in the initiatives. In the Standish-Kuon and Rice (2002) study, it was revealed that the faculty teaching the entrepreneurship courses in *Business School* model initiatives were situated in the business school. The research findings, however, revealed that the location of the faculty was dependent on the location of the entrepreneurship initiatives. As a result, in the United States, the faculty was mainly from the business school. However, faculty also included academics from the Schools of Engineering, Arts and Sciences, Media, and Entrepreneurship. In comparison, the faculty teaching entrepreneurship courses in Australian, Canadian, and New Zealand *Business School* model entrepreneurship initiatives all came from the business school.

Engineering school administrators from 8 institutions with *Business School* model initiatives responded to the questionnaire. The data from these 8 administrators revealed that 3 main types of faculty were used in the *Business School* model entrepreneurship initiatives, as shown below in Figure 29.

Figure 29: The types of faculty teaching entrepreneurship courses in *Business School* model entrepreneurship initiatives



As presented in Figure 29, business school academics were the primary type of faculty members teaching the entrepreneurship courses in the initiatives of the respondents' institutions. In addition, engineering academics and practicing or experienced entrepreneurs also taught classes in some of these entrepreneurship initiatives.

Overall, the findings showed that the locations where entrepreneurship courses are taught and the faculty teaching these courses in present-day *Business School* model entrepreneurship initiatives have expanded. Standish-Kuon and Rice (2002) stated that the courses in *Business School* model entrepreneurship initiatives were taught in both the business and engineering school by faculty members from the business school. The findings from this research revealed that all courses in Australian, Canadian and New Zealand entrepreneurship initiatives were taught in the business school. In the United States, on the other hand, courses were primarily taught in the business school, and in other locations such as the Schools of Engineering, Media, Arts and Sciences, and Entrepreneurship. Furthermore, the findings from the data collected from the 8 engineering school administrator responses revealed that entrepreneurship courses were primarily taught by business school academics, but also by engineering school academics and practicing or experienced entrepreneurs.

6.3.5: The motivating factors behind the creation of *Business School* model entrepreneurship initiatives

To further distinguish *Business School* model initiatives from those of other models, one of the aims of the research study was to identify the factors that motivated the creation of *Business School* model entrepreneurship initiatives. To determine these motivating factors, the online questionnaire sent to engineering school administrators asked respondents to identify the factor that resulted in the formation of their entrepreneurship initiatives. Of the 8 engineering school administrators from institutions whose initiatives followed the *Business School* model, 6 provided a response to this question on the questionnaire.

The findings revealed that despite *Business School* model entrepreneurship initiatives being primarily developed by the business school, the motivating factor behind the creation of their entrepreneurship initiatives was a desire for knowledge and ideas to be shared between the business and engineering schools. These initiatives however were all categorised as *Business School* model entrepreneurship initiatives because they were all housed solely in the business school. This suggested that the business school collaborated with the engineering school to ensure that engineering undergraduates received entrepreneurial training.

Overall, despite the findings showing that different schools were responsible for the creation and development of the entrepreneurship initiatives, the initiatives from the respondents' institutions resulted from the same motivating factor: a desire for the transfer of knowledge between the business and engineering schools.

6.3.6: The objectives of *Business School* model entrepreneurship initiatives

To determine the objectives of *Business School* model entrepreneurship initiatives, the online questionnaire asked engineering school administrators to state the objectives of their entrepreneurship initiatives for engineering undergraduates. The findings revealed that entrepreneurship initiatives for engineering undergraduates collectively had four objectives, all aimed at educating students "about" and "for" entrepreneurship as discussed in section 5.6:

- to provide a general understanding of entrepreneurship;
- to develop the entrepreneurial mindset;
- to provide the knowledge and skills needed to be and act entrepreneurially; and
- to provide practical entrepreneurial experience.

A review of the data provided by engineering school administrators whose initiatives follow the *Business School* model showed that the entrepreneurship initiatives collectively had these four objectives. However, each individual initiative was found to have one or two of these four objectives. For example, Respondents R79 and R81 stated:

Respondent ID	Objective
R79	*"This program has been designed for engineering students who plan to pursue a career combining technical and business skills. This could include a business startup or working for an entrepreneur in the early years of the business."*
R81	*"To expose students to entrepreneurial ideas."*

This suggested that entrepreneurship initiatives for engineering undergraduates have different focal points. This shows that *Business School* model initiatives are not required to have the exact same objectives.

6.3.7: The types of educational programmes offered in *Business School* model entrepreneurship initiatives

The review of entrepreneurship initiative descriptions on the institutions' webpages showed that there were five types of educational programmes used to educate engineering undergraduates about entrepreneurship. As explained in section 5.7, these programmes included:

- entrepreneurship-based bachelor degree programmes;
- short entrepreneurship programmes;
- entrepreneurial experiential or practical learning programmes;
- individual entrepreneurship courses; and
- individual entrepreneurial engineering courses and projects.

Analysis of U.S.-based *Business School* model initiatives showed that the primary educational type offered was short entrepreneurship programmes in the form of academic minor and certificate programmes offered by business schools. This was consistent with previous research that showed that the majority of entrepreneurship educational offerings open to engineering students consisted of academic minor and certificate programmes that were either business-school based or institution-wide (Duval-Couetil et al. 2015). These programmes were primarily in general entrepreneurship, however, there were also programmes in, for example, entrepreneurship and innovation, technology entrepreneurship, social entrepreneurship, technology management, and innovation. Other initiatives also offered individual entrepreneurship courses. Here, students were able to take entrepreneurship courses in, for example, business minors, special programmes in management and technology, bachelor degree programmes that combined engineering and management, or courses taken as electives in engineering degrees. Some entrepreneurship initiatives also consisted of entrepreneurial experiential or practical learning programmes, which focused solely on hands-on entrepreneurial activities including the development of ideas and business strategies around the commercialisation of patents, the development of new business ideas, the development of new business ventures and products, the creation of social enterprises, and internships taken at existing companies where students gained practical entrepreneurial experience. Only one initiative offered an entrepreneurship-based bachelor degree programme in engineering and innovation management.

Like the programmes offered in the U.S. entrepreneurship initiatives, the primary entrepreneurship educational programmes offered in Australian *Business School* model initiatives were academic minor and certificate programmes, which were offered in entrepreneurship initiatives developed solely by the business school. The initiative developed by the business and engineering schools consisted of individual courses in entrepreneurship stemming from double bachelor degrees combining engineering and business. Conversely, the main entrepreneurship educational programmes offered in Canadian *Business School* model entrepreneurship initiatives was individual courses in entrepreneurship. These courses were mainly included in business or management minors, but there were also courses added as electives to engineering bachelor degree, and stand-alone courses in the form of one-day courses and workshops. The other type of educational programmes offered in Canadian *Business School* model initiatives was short entrepreneurship programmes. These included academic minor or certificate programmes in areas such as general entrepreneurship, innovation, enterprise, and entrepreneurship and innovation. The New Zealand *Business School* model entrepreneurship initiative had a unique educational programme, where the business school offered a bachelor degree in entrepreneurship which was designed to be taken with both business and non-business degrees.

Overall, the findings showed that *Business School* model entrepreneurship initiatives offered different types of educational programmes to educate engineering undergraduates about entrepreneurship. Of the five types of programmes presented in section 5.7, 4 types were offered, the exception being individual entrepreneurial engineering courses and projects. The findings also showed that institutions within the same country differed in the types of programmes offered, which showed that there was no specific type of entrepreneurship educational programme that could be identified as being offered in *Business School* model entrepreneurship initiatives.

6.3.8: The practical experiences offered in *Business School* model entrepreneurship initiatives

As explained in section 5.8, engineering undergraduates gained practical experience in entrepreneurship through co-curricular activities (for-credit practical entrepreneurship activities) and extra-curricular activities (not-for-credit practical entrepreneurship activities). To determine the types of practical experiences offered in *Business School* model entrepreneurship initiatives, information was collected from initiative descriptions on the institutions' webpages and reviewed to identify the co- and extra-curricular activities offered any potential similarities.

Across institutions in the four countries using the *Business School* model entrepreneurship initiatives, the primary type of practical activities offered was "Business Creation" activities. Several initiatives offered opportunities for students to create and develop their own business plans for potential new ventures, while some initiatives also offered opportunities for students to work on ideas for new ventures and conduct feasibility analyses. There were also opportunities offered for students to launch new ventures or pitch ideas for new ventures to potential investors. The second most common type of co-curricular or extra-curricular activities offered was "New Technology Creation" activities or "New Product Creation" activities. These initiatives focused on the development of ideas for new products, the creation and development of prototypes for these new products, the creation and development of business plans for these new products, the pitch of these products to potential investors, and the launch of these products into the market.

The findings also revealed additional co-curricular and extra-curricular activities, as presented in Table 22.

Table 22: *Business School* model entrepreneurship initiative co-curricular and extra-curricular activities offered to engineering undergraduates in Australia, Canada, New Zealand, and the United States

Examples of *Business School* model entrepreneurship initiative co-curricular and extra-curricular activities	
Country	**Co-curricular/Extra-curricular activity**
Australia	Business creation activities
	New technology/new product creation activities
Canada	Business creation activities
	New technology/new product creation activities
	Participation in entrepreneurial and design projects
	Participation in entrepreneurship clubs, societies, and organisations
	Participation in entrepreneurship competitions and challenges
	Work experience in established companies through internships and co-op opportunities
	Networking opportunities with other individuals who have entrepreneurial interests
	Opportunities to be mentored by individuals with entrepreneurial experience
New Zealand	Business creation activities
	New technology/new product creation activities
	Creation and presentation of project plans
The United States	Business creation activities
	New technology/new product creation activities
	Identification and evaluation of potential business opportunities
	Management and operation of new enterprises
	Work experience in established companies through internships and co-op opportunities
	Participation in interdisciplinary team projects for real-world clients
	Participation in real-world business projects
	Development of social entrepreneurship opportunities and generation of solutions to social problems
	Acting in consultant roles for small businesses or start-ups and social enterprises
	Acting in consultant roles on product design, prototyping and development
	Development of technical solutions to environmental problems
	Development of business models, solutions, strategies, and proposals
	Participation in entrepreneurship clubs, societies, and organisations
	Participation in entrepreneurship competitions and challenges, lectures, workshops, and seminars
	Networking opportunities with other individuals who have entrepreneurial interests
	Opportunities to be mentored by individuals with entrepreneurial experience
	Participation in entrepreneurship study tours and trips

The findings revealed that every opportunity for gaining practical entrepreneurial experience under the *Business School* model was not seen in each of the four countries, which could have been due to the differences in the numbers of institutions using the

Business School model. Overall, there were similarities amongst the institutions in the four countries with regards to how engineering undergraduates gained practical entrepreneurial experience through *Business School* model initiatives.

6.3.9: The entrepreneurial competencies emphasised in *Business School* model entrepreneurship initiatives

The online questionnaire sent to engineering school administrators asked respondents to identify which, if any, of the 13 Morris et al. (2013b) competencies were emphasised in their entrepreneurship initiatives for engineering undergraduates. The administrators were asked to indicate the level of emphasis placed on these competencies using a rating on the following five-point Likert scale: '*No emphasis'*, '*Some emphasis'*, '*Moderate emphasis'*, '*Major emphasis'*, and '*Significant emphasis*'.

The findings from the 8 *Business School* model entrepreneurship initiatives for which questionnaire data was available revealed that despite the 13 competencies being emphasised at varying levels, 12 of the 13 Morris et al. (2013b) competencies were either significantly or majorly emphasised, as shown in Table 23.

Table 23: The entrepreneurial competencies significantly or majorly emphasised in *Business School* model entrepreneurship initiatives

The entrepreneurial competencies significantly and majorly emphasised in *Business School* model entrepreneurship initiatives [N = 8]	
Entrepreneurial competency	**% of respondents**
Tenacity or Perseverance	62.5
Creative Problem Solving	62.5
Opportunity Assessment	50
Value Creation	50
Building and using networks	50
Opportunity Recognition	37.5
Conveying a compelling vision	37.5
Resource Leveraging	37.5
Risk Management	25
Maintain Focus yet adapt	25
Self-Efficacy	25
Resilience	12.5
Guerrilla Skills	0

*competencies are listed from the competency that has been significantly/majorly emphasised by the greatest number of respondents to the competency that has been significantly/majorly emphasised by the least number of respondents

As shown in Table 23, *Tenacity* and *Creative Problem Solving* were identified as being the two main competencies either significantly or majorly emphasised in these *Business School* model initiatives. Concurrently, *Resilience* was the competency that was the least significantly or majorly emphasised, while *Guerrilla Skills* was the only competency to be neither significantly nor majorly emphasised.

These findings suggested that for these 8 *Business School* model entrepreneurship initiatives, it was essential that students know how to combine resources to generate novel and useful outputs and be able to continue towards their goals in spite of potential setbacks that may be faced. The findings also suggested that less value was placed on the need for engineering undergraduates to handle any stresses that may be derived when faced with adversity.

Overall, despite the fact that all of the competencies were emphasised in the 8 Business School model entrepreneurship initiatives, 12 of the 13 competencies were either majorly or significantly emphasised. There were differences with regards to which competencies were majorly or significantly emphasised within each of the eight initiatives, and this showed that in each initiative some competencies were considered more valuable to learn than others.

6.3.10: The opportunities experienced in *Business School* model entrepreneurship initiatives

Entrepreneurship initiatives, as explained in section 5.9, offered 10 opportunities for students to gain experience in entrepreneurship. To determine which of these opportunities were offered in *Business School* model entrepreneurship initiatives, the online questionnaire sent to engineering school administrators asked respondents to select which of the opportunities were offered to their engineering students. The results determined from the 8 *Business School* model entrepreneurship initiatives which provided information are identified in Table 24.

Table 24: The opportunities engineering undergraduates experience in *Business School* model entrepreneurship initiatives

The opportunities engineering undergraduates experience in *Business School* model entrepreneurship initiatives [N = 8]	
What engineering undergraduates experience	**% of respondents**
Develop a product or technology for a real client/customer	62.5
Be involved in entrepreneurship- or business-related student organisations	62.5
Write a business plan	62.5
Participate in an entrepreneurship-related competition	62.5
Participate in entrepreneurship-related workshops	62.5
Intern or work for an entrepreneurial or start-up company	50
Give an "elevator pitch" or presentation to a panel of judges about a product or business idea	50
Be involved in patenting a technology or protecting intellectual property	50
Take an entrepreneurship course within the Faculty/School of Engineering	37.5
Conduct market research and analysis for a new product or technology	37.5

The results revealed that the 10 opportunities were offered in these 8 *Business School* model entrepreneurship initiatives. As shown, in Table 24, the entrepreneurship initiatives primarily offered opportunities for students to develop new products and technologies, write business plans, become involved in entrepreneurship student organisations, and participate in entrepreneurship competitions and workshops. It can therefore be seen that in these eight institutions, students learned how to derive new products and technologies, write business plans to support these new products and technologies, and network with others who possess entrepreneurial interests.

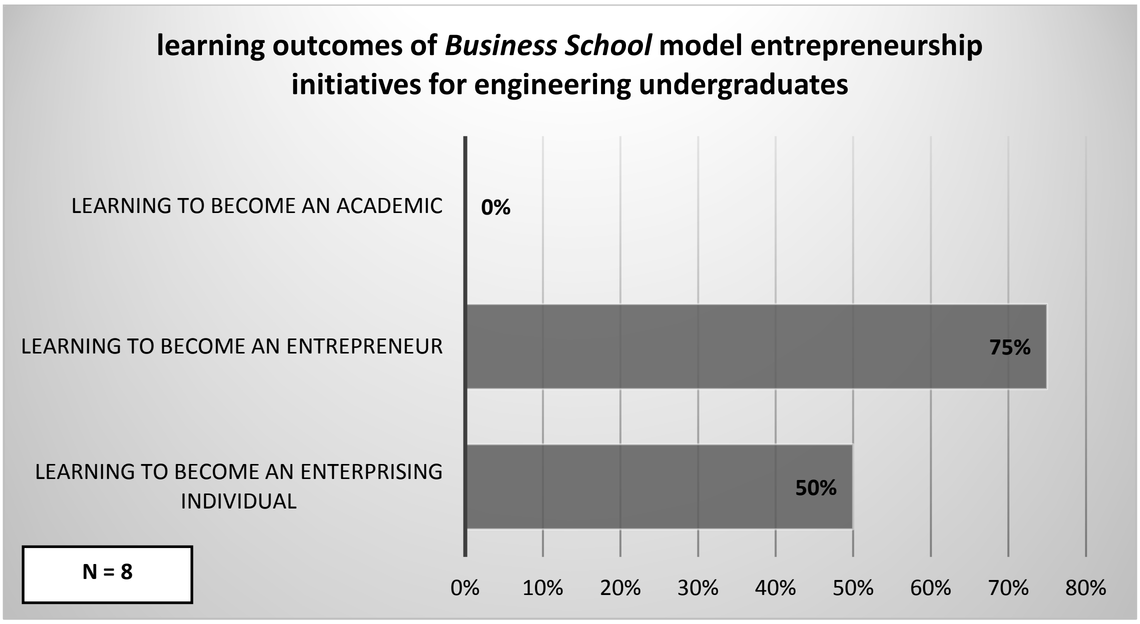
The smallest percentage of respondents offered opportunities to take entrepreneurship courses within the school of engineering. This was expected given that the findings have showed that most *Business School* model entrepreneurship initiatives did not include the engineering school in the initiative development. A somewhat surprising result was that the opportunity to conduct market research and analysis for new products and technologies was also offered by the smallest percentage of *Business School* model respondents. These results could demonstrate support for multidisciplinary team work where engineering students focus on the development of new products and technologies while other students, for example, business students, focus on the background work necessary for product and technology development.

6.3.11: The outcomes of *Business School* model entrepreneurship initiatives

To determine the outcomes of *Business School* model entrepreneurship initiatives, the online questionnaire first asked engineering school administrators to state whether their entrepreneurship initiatives educated their students to become enterprising individuals, entrepreneurs, or academics. The online questionnaire then asked the administrators to identify the careers they prepared their students to do on completion of their participation in entrepreneurship initiatives.

First, the findings revealed that the *Business School* model entrepreneurship initiatives, for which questionnaire data was available, had two learning outcomes, as shown in Figure 30.

Figure 30: The outcomes of *Business School* model entrepreneurship initiatives



As Figure 30 illustrates, the primary outcome of *Business School* model entrepreneurship initiatives at the institutions surveyed was for students to become entrepreneurs. This meant that students were primarily educated to start their own businesses and learn about what can happen in various entrepreneurial situations surrounding the creation and operation of new ventures. Students were also educated to become enterprising individuals, where they developed entrepreneurial mindsets and demonstrated entrepreneurial thinking and actions. However, the primary outcome of learning to become an entrepreneur can be associated with a business-focused curriculum, which was focused on the creation of new business ventures and business creation activities in existing companies.

Second, the findings also revealed that the 8 initiatives prepared the students to follow one of six entrepreneurship or business related career directions in addition to being traditional engineers, which is presented in Table 25.

Table 25: What engineering undergraduates are prepared to do after participation in *Business School* model entrepreneurship initiatives

What engineering undergraduates are prepared to do after participation in *Business School* model entrepreneurship initiatives [N = 8]	
What engineering undergraduates are prepared to do	**% of respondents**
Start their own business or be self-employed	38%
Attend graduate/professional school	38%
Work for a small business or start-up company	25%
Work for a medium- or large-size business	25%
Work for a social enterprise	13%
Work for a non-profit organisation	13%

As shown in Table 25, the 8 entrepreneurship initiatives following the *Business School* model primarily prepared engineering undergraduates to undertake careers where they can be self-sufficient, by starting their own businesses and ultimately generating their own income and making profits. The preparation of students to primarily start their own businesses is in line with the primary learning outcome of becoming an entrepreneur. Simultaneously, the initiatives also prepared students to further their education by attending graduate or professional school. This was an interesting finding, particularly given that becoming an academic was not one of the intended outcomes of *Business School* model entrepreneurship initiatives. However, the preparation of students to further their educational careers could be to provide opportunities for further knowledge and skills to be acquired which enable students to gain a stronger foothold in the professional world.

Table 25 also showed that less emphasis was placed on preparing students to work in organisations such as social enterprises and non-profit organisations, where the primary goal is to aid in the personal development of individuals and address societal or social problems. This may be due to the need for engineering undergraduates to contribute directly to the economic development of entrepreneurial societies. As a result, this need could place more focus on careers that allow for the direct generation of income and profits, and the creation of employment.

Overall, the 8 *Business School* model entrepreneurship initiatives, for which information was available, showed that programmes educated students to either be enterprising individuals or entrepreneurs. They prepared students primarily to launch their own ventures and enterprises, or attend graduate or professional schools in order to further their own business careers.

6.4: The EEE Typology Model 2: The *Engineering School Model*

The *Engineering School* model, as explained in section 5.3, was seen in Australia, Canada, New Zealand, the United Kingdom, and the United States. This description of the *Engineering School* model is divided into 11 sections – 4 sections representing the characteristics that emerged from the Standish-Kuon and Rice (2002) study, and 7 sections representing additional characteristics of entrepreneurship initiatives for engineering undergraduates. In the description, the findings obtained from the U.S.-based initiatives are first highlighted, and then a comparison is made to the findings obtained from the initiatives in the four remaining countries.

6.4.1: The schools responsible for the creation and development, and the home base, of *Engineering School* model entrepreneurship initiatives

The Standish-Kuon and Rice (2002) study classified *Engineering School* model entrepreneurship initiatives as those developed by the engineering school through a sharing of knowledge and ideas with the business school, and housed in the engineering school. This study found that in U.S. institutions, *Engineering School* model entrepreneurship initiatives were primarily developed solely by the engineering school, as seen in 77% of the 69 initiatives. Of the remaining initiatives, 19% were developed by the engineering school in collaboration with the business school, with one initiative developed by the engineering school in collaboration with the institution's innovation centre. There were also entrepreneurship initiatives classified as institution-wide initiatives that were developed in engineering-only tertiary-level academic institutions.

Like the U.S. initiatives, the majority of the *Engineering School* model initiatives at Canadian and U.K. institutions were developed solely by the engineering school. In Canadian institutions, 53% of the 19 initiatives were developed solely by the engineering school, with the remaining initiatives developed by the engineering and business schools. Of the 41 U.K. initiatives, 93% were developed solely by the engineering school, with the remaining initiatives developed by the engineering and business schools.

Conversely, the *Engineering School* model entrepreneurship initiatives at Australian and New Zealand institutions were primarily developed by the engineering and business schools, as seen in 85% of the 13 Australian initiatives and 60% of the 5 New Zealand initiatives. The remaining 15% of the Australian initiatives and 20% of the New Zealand initiatives were developed solely by the engineering school. There was also one New Zealand initiative that was developed by the engineering and design schools.

The study also found that U.S.-based *Engineering School* model initiatives were primarily housed in the engineering school, but also in other locations. For engineering-only institutions, the initiatives were based institution-wide, across all the departments of the institution. There was also one initiative based in both the engineering school and innovation centre, and another based in a freestanding entrepreneurship school. Similarly, the Canadian and U.K. initiatives were primarily housed in the engineering school, with one initiative in each of these two countries housed in the business school. The Australian and New Zealand initiatives were all housed in the engineering school.

Overall, the research findings showed differences to those of the Standish-Kuon and Rice (2002) study in that the majority of the *Engineering School* model initiatives were developed solely by the engineering school. Moreover, the findings showed similarities to the Standish-Kuon and Rice (2002) findings in that initiatives were primarily housed in the engineering school.

6.4.2: The curriculum used in *Engineering School* model entrepreneurship initiatives

Standish-Kuon and Rice (2002) found that *Engineering School* model initiatives had a technological entrepreneurship curriculum developed solely by the engineering school. This study examined whether the curricula used in present-day initiatives were focused on any of three main areas: the creation, development, and operation of new business enterprises (a business-focused curriculum), the creation of new technologies and products that address societal needs (a technologically-focused curriculum), and gaining knowledge of the field of entrepreneurship and what it entails (an entrepreneurship-focused curriculum). In determining the curriculum used in *Engineering School* model entrepreneurship initiatives, the descriptions of each curriculum type were compared to the descriptions of entrepreneurship initiatives and individual courses available on the institutions' webpages.

Given that the curriculum used in *Engineering School* model initiatives was formulated by the schools that created and developed the entrepreneurship initiatives, the findings revealed that the curriculum used was primarily developed by the engineering school. In other cases it was developed by engineering school and another school, for example, the Schools of Business and Entrepreneurship. The curriculum used in initiatives that were institution-wide was created by the engineering departments at the institution.

The findings also showed that U.S. *Engineering School* model initiatives primarily followed a business- and technologically-focused curriculum. The remaining initiatives used either a business-, technologically-, and entrepreneurship-focused curriculum, or a technologically-focused curriculum. However, one initiative used a business-focused curriculum, while another used a technologically- and entrepreneurship-focused curriculum.

Like the U.S. initiatives, Canadian and U.K. *Engineering School* model initiatives primarily used a business- and technologically-focused curriculum. The findings also revealed that the initiatives offered by institutions in both countries also used four additional curriculum types: a business-, technologically-, and entrepreneurship-focused curriculum, a business- and entrepreneurship-focused curriculum, a business-focused curriculum, or a technologically-focused curriculum.

In contrast to the initiatives offered in U.S., Canadian, and U.K. institutions, the primary curriculum type used in Australian and New Zealand *Engineering School* model initiatives was business-, technologically-, and entrepreneurship-focused. The remaining initiatives offered by institutions in both countries used one of three curriculum types: a business- and technologically-focused curriculum, a business- and entrepreneurship-focused curriculum, and a technologically-focused curriculum.

Overall, the findings showed that like the initiatives following the *Business School* model, *Engineering School* model entrepreneurship initiatives do not use one specific curriculum type. Moreover, the findings showed that these initiatives mainly used a curriculum that had a combination of either two or three of the three overarching types used in entrepreneurship initiatives for engineering undergraduates (i.e. business-focused, technologically-focused, and entrepreneurship-focused). The initiatives offered by U.S., Canadian, and U.K. institutions primarily used a business- and technologically—focused curriculum, while those offered by Australian and New Zealand institutions primarily used a business-, technologically-, and entrepreneurship-focused curriculum. These findings suggested that entrepreneurship initiatives belonging to the same model do not necessarily possess the same focus, and as a result, can be distinguished from each other.

6.4.3: Target students of *Engineering School* model entrepreneurship initiatives

Engineering School model initiatives, as identified in the Standish-Kuon and Rice (2002) study, were designed either for engineering students, or for business and some non-business students. To determine which students *Engineering School* model initiatives were designed for, the initiative descriptions on the institutions' webpages were reviewed.

The findings first revealed that the *Engineering School* model initiatives offered by U.S. institutions were primarily designed for engineering undergraduates, but also for business and engineering undergraduates, engineering, science and technical students, or for all undergraduates regardless of major. One U.S. initiative was designed for all non-business students, and another was designed specifically for certain engineering students following specific majors and included all business students.

Outside the United States, the study found that *Engineering School* model initiatives at Australian institutions were primarily designed for engineering undergraduates, but also for engineering and business undergraduates. The initiatives at Canadian institutions were also primarily designed for engineering undergraduates, but also for all undergraduates, regardless of major. In New Zealand, the initiatives were primarily designed for engineering and business undergraduates. However, for the New Zealand initiative developed solely by the engineering school, the target group was engineering undergraduates, while the initiative developed by the engineering and design school was for engineering and design undergraduates. Concurrently, the U.K. initiatives were unique with regards to the students targeted. Despite the U.K initiatives being designed for engineering undergraduates, it was more specifically designed for engineering students following certain engineering majors. The majors targeted varied and depended on the institution. For example, in one institution, entrepreneurship courses were required for students pursuing degrees in Design Engineering but optional for students studying Mechanical Engineering. In another institution, entrepreneurship was offered to students studying Mechanical and Electrical Engineering but not to students studying Civil and Chemical Engineering. The entrepreneurship initiatives were also widely designed for all engineering students, while only one initiative was designed for all undergraduate students at the institution.

Overall, the findings showed that in contrast to the *Business School* model's initiatives, *Engineering School* model initiatives were primarily designed to educate engineering undergraduates to be entrepreneurial, without the need to mould a multidisciplinary student cohort. Despite this, interaction with students from other disciplines was seen in some initiatives. These findings suggested that that the initiatives have different views, when compared to the initiatives of the *Business School* model, on how engineering undergraduates should undertake entrepreneurial learning and experience an entrepreneurial environment.

6.4.4: The locations where the courses in *Engineering School* model entrepreneurship initiatives are taught and the faculty responsible for the teaching of entrepreneurship

Standish-Kuon and Rice (2002) found that the courses of *Engineering School* model entrepreneurship initiatives were mainly taught in the engineering school, although students could also participate in courses offered in the business school. The findings also showed that the courses were taught by academics from both the engineering and business schools. In order to determine where entrepreneurship courses in the *Engineering School* model's initiatives in this research were taught, course listings were located on the institutions' websites and the schools within which they were offered were identified. To find out information regarding the faculty members who taught these courses, the faculty pages were reviewed to see which schools they were located in. Furthermore, in the online questionnaire sent to engineering school administrators, respondents were asked to state which of six groups (*Engineering Academics*, *Business Academics*, *Engineering Graduate Students*, *Business Graduate Students*, and *Practicing/Experienced Entrepreneurs*) held the responsibility for teaching entrepreneurship courses. Respondents to the questionnaire also had the opportunity to identify other groups that were used to teach the courses.

First, the findings showed that courses in the U.S. *Engineering School* model initiatives were primarily taught in the engineering school, with 93% of the sixty-nine initiatives being situated in this school. The courses of two initiatives, that were present in engineering-only institutions, were available campus-wide and present in all the departments of the institution. One initiative's courses were located in a freestanding entrepreneurship school, while another's were located in both the engineering school and an innovation and entrepreneurship centre. The final initiative had courses situated in the Schools of Business, Engineering, Music, and Arts and Sciences.

Next, the findings revealed that the engineering school was the primary location where entrepreneurship was taught in both Canadian and U.K. Engineering School model initiatives. In Canada, 53% of the initiatives had courses taught in the engineering school, 37% had courses located in both the engineering and business schools, and the remaining 10% were located in the business school. Of the 41 *Engineering School* model entrepreneurship initiatives in the United Kingdom, all, with the exception of one initiative, had courses taught in the engineering school. The remaining initiative delivered its classes in the business school. In contrast to the U.S., Canadian, and U.K. initiatives, the courses in Australian and New Zealand initiatives were mainly delivered in the business school. Other initiatives in both countries were also delivered in the engineering school. Some Australian initiatives had courses delivered in both the engineering and business schools; while the New Zealand initiative developed by the engineering and design schools delivered its entrepreneurship courses in the design school.

Third, based on the questionnaire data collected from 34 of the 36 engineering school administrators, whose initiatives followed the *Engineering School* model, the findings showed that like the *Business School* model, engineering academics, business academics, and practising or experienced entrepreneurs taught entrepreneurship courses, as presented in Figure 31.

Figure 31: The types of faculty teaching entrepreneurship courses in *Engineering School* model entrepreneurship initiatives

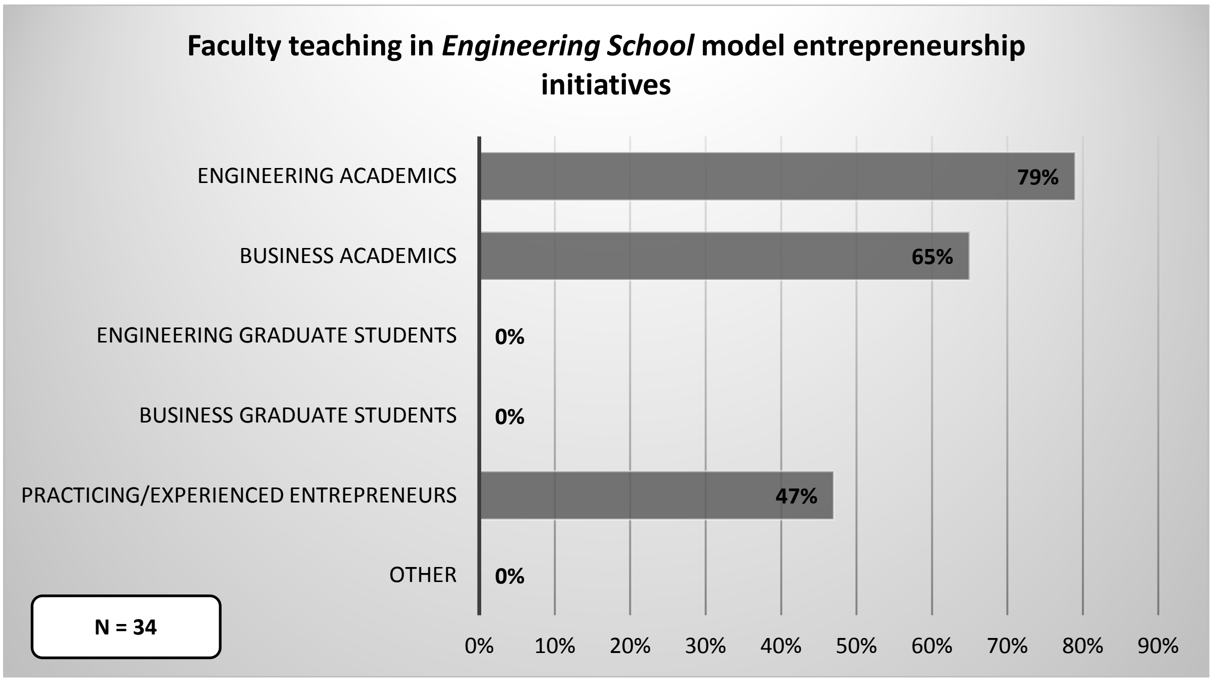


Figure 31 shows that entrepreneurship courses in *Engineering School* model initiatives were primarily taught by engineering school academics. Several of the 34 administrators also indicated that their courses were taught by business academics, with less stating that they also used practicing or experienced entrepreneurs.

Overall, the findings revealed that despite entrepreneurship courses being largely located in the engineering school, they were also present in other schools of the institution. This suggested that entrepreneurship courses for engineering undergraduates do not necessarily have to be delivered in the engineering school in order for an initiative to be categorised as *Engineering School* model initiatives. With regards to the faculty that taught these courses, the findings suggested a collaborative relationship between the engineering and business schools, with both schools sharing the responsibility for the teaching of entrepreneurship.

The inclusion of practising or experienced entrepreneurs also showed the recognition that it was beneficial for engineering undergraduates to acquire knowledge and skills from both academics and individuals operating in an entrepreneurial environment.

6.4.5: The motivating factors behind the creation of *Engineering School* model entrepreneurship initiatives

In order to determine the factors that motivated the creation of *Engineering School* model entrepreneurship initiatives, the online questionnaire sent to engineering school administrators provided a number of motivating factors and asked respondents to select the ones that described what led to the emergence of their initiatives.

Based on the data collected from the 36 administrators whose initiatives followed the *Engineering School* model, the findings revealed that there were 10 motivating factors which led to the creation of the initiatives, which are presented in Table 26.

Table 26: The motivating factors behind the establishment of *Engineering School* model entrepreneurship initiatives

The motivating factors behind the establishment of *Engineering School* model entrepreneurship initiatives [N = 36]	
Motivating Factor	**% of respondents**
Funding from the engineering school	42
A desire for active collaboration to occur among the business school, engineering school, and some of the other schools in the institution	25
An institution-wide initiative	8
Funding given to the business school by the engineering school	6
A desire for knowledge and ideas to be shared between the business and engineering schools (engineering school based initiatives)	6
A desire for knowledge and ideas to be shared between the business and engineering schools (business school based initiatives)	3
Funding from the engineering school and collaboration between the engineering and business schools	3
Funding from the engineering school and the engineering school's collaboration with the business and some of the other schools at the institution	3
Funding from the engineering school with the business school collaborating with some of the engineering departments	3
Actions of a faculty member	3

As shown in Table 26, 42% of the 36 administrators stated that the motivating factor behind the creation of their initiatives was funding received from the School of Engineering to educate their students about entrepreneurship. Analysis of the data also showed that some initiatives resulted from the engineering school and its collaboration with other schools at the institution, or from the desire for engineering-only institutions to educate the student body about entrepreneurship. In one case, a faculty member was responsible for the presence of the entrepreneurship initiative, which showed the importance of having individuals with entrepreneurial interests who can champion the development of the initiative.

Overall, although the findings revealed a number of different motivating factors which led to the creation of entrepreneurship initiatives, the primary factor which led to the creation of *Engineering School* model initiatives was the provision of funding from the School of Engineering. This finding of the engineering school acting in isolation was in contrast to the motivating factor behind the administrators' initiatives that followed the *Business School* model, which showed that collaboration between the business and engineering schools was responsible for the initiative creation. Furthermore, these findings showed that there was no single motivating factor which led to the creation of the entrepreneurship initiatives. This demonstrated that despite these initiatives belonging to the same model, there was no single factor that led to creation of the initiatives.

6.4.6: The objectives of *Engineering School* model entrepreneurship initiatives

As explained in section 5.6, entrepreneurship initiatives for engineering undergraduates are designed to educate students "about" and "for" entrepreneurship by providing students with either a general understanding of entrepreneurship, develop the students' entrepreneurial mindset, provide students with the knowledge and skills needed to be entrepreneurial and act in an entrepreneurial manner, and/or provide students with practical experience in entrepreneurship. In order to determine the objectives of *Engineering School* model entrepreneurship initiatives, the online questionnaire sent to engineering school administrators asked respondents to state the objectives of their initiatives. The responses from administrators whose initiatives followed the *Engineering School* model were then taken and categorised according to the four objectives, where applicable.

The findings revealed that like the *Business School* model initiatives, first, the four objectives were collectively seen in *Engineering School* model initiatives, and second, each individual initiative had either one or two of the four objectives. For example, respondents R25, R40, R93, and R124 stated:

Respondent ID	Objective
R25	*"Introduce product centered thinking and economically viable concept generation ability in our curricula."*
R40	*"Give the students tools and experience in setting up and managing an enterprise."*
R93	*"The usual…get creative, motivated students developing ideas."*
R124	*"Awaken students' entrepreneurial desire and provide them with the support necessary to realise their ideas."*

Similar to the findings of the *Business School* model initiatives, the variation in objectives demonstrated that entrepreneurship initiatives for engineering undergraduates had different areas of focus. These findings show that *Engineering School* model entrepreneurship initiatives did not necessarily need to have the same objectives.

6.4.7: The types of educational programmes offered in *Engineering School* model entrepreneurship initiatives

Section 5.7 showed that entrepreneurship initiatives for engineering undergraduates can either offer entrepreneurship-based bachelor degree programmes, short entrepreneurship programmes, entrepreneurial experiential or practical learning programmes, individual entrepreneurship courses, or individual entrepreneurial engineering courses and projects.

In reviewing descriptions of entrepreneurship initiatives that followed the *Engineering School* model on the institutions' webpages, the findings revealed that the U.S-based entrepreneurship initiatives consisted of the five types of educational programmes. Like U.S.-based *Business School* model entrepreneurship initiatives, the primary type offered was short entrepreneurship programmes in the form of academic minor and certificate programmes. These programmes consisted of minors and certificates in, for example, general entrepreneurship, innovation, technological entrepreneurship, innovation and entrepreneurship, entrepreneurial engineering or engineering entrepreneurship, and technology commercialisation. The remaining entrepreneurship initiatives offered entrepreneurship-based bachelor degree programmes, individual entrepreneurship courses taken as electives in engineering bachelor degrees, specialised short entrepreneurship short programmes, entrepreneurial experiential/practical-based programmes where students either generated solutions to real-world technical problems or applied knowledge in company internships, and individual entrepreneurial engineering courses and projects.

Like the U.S. *Engineering School* model initiatives, the Canadian initiatives also primarily offered short entrepreneurship programmes. The findings showed that these initiatives mainly used academic minor or certificate programmes in, for example, engineering entrepreneurship, technology entrepreneurship, engineering innovation and entrepreneurship, and general entrepreneurship. The findings also showed that Canadian initiatives also offered entrepreneurship-based bachelor degree programmes in engineering and entrepreneurship, individual courses in entrepreneurship either included in business minors or taken as engineering degree electives, and individual entrepreneurial engineering projects. Conversely, initiatives in the United Kingdom primarily offered individual entrepreneurship courses added to engineering degrees. U.K. institutions typically have two types of undergraduate engineering degrees – a three-year BEng degree and a four-year MEng degree. Both degrees are essentially the same, with those following the MEng programme taking an additional year of courses. The individual entrepreneurship courses were typically included in the MEng programme; however there were instances of courses being added to some BEng programmes. Besides individual entrepreneurship courses, U.K. initiatives additionally offered two types of educational programmes – individual entrepreneurial engineering courses and projects, and entrepreneurship-based degree programmes in areas such as engineering combined with management and entrepreneurship, design, innovation, and entrepreneurship, product design, and engineering and entrepreneurship.

The findings also revealed that Australian initiatives primarily offered either entrepreneurship-based bachelor degree programmes or individual entrepreneurship courses. The entrepreneurship-based degree programmes were in the form of double bachelor degrees which combined engineering and entrepreneurship, while the individual entrepreneurship courses were added to double degrees which combined engineering and either business or management. In addition to these educational programmes, other initiatives either offered individual entrepreneurial engineering courses, or individual entrepreneurship courses which were added to bachelor degrees in engineering. The New Zealand initiatives, on the other hand, primarily offered entrepreneurship-based bachelor degree programmes. The main types of programmes offered were double bachelor degrees that combined engineering with entrepreneurship and innovation. In addition to double bachelor degrees, the New Zealand initiatives offered single bachelor degrees that combined engineering, entrepreneurship, and innovation management, and individual entrepreneurship courses which were included in double degrees in engineering and business.

Overall, the findings revealed that although *Engineering School* model initiatives offered the five types of educational programmes, the primary type used varied across the different academic institutions of each country. In the U.S. and Canadian initiatives, the primary type used was short entrepreneurship programmes in the form of academic minor and certificate programmes. In the U.K. initiatives, the primary type was individual entrepreneurship courses that were added to engineering degrees. Similarly, the Australian initiatives primarily offered entrepreneurship-based bachelor degrees or individual entrepreneurship courses, while the New Zealand initiatives primarily offered entrepreneurship-based bachelor degrees. As a result, the findings showed that there was no single entrepreneurship educational programme that can be specifically classified as being offered in *Engineering School* model initiatives.

6.4.8: The practical experiences offered in *Engineering School* model entrepreneurship initiatives

In reviewing institutions' webpage descriptions of the co-curricular activities (for-credit practical entrepreneurship activities) and extra-curricular activities (not-for-credit practical entrepreneurship activities) offered in *Engineering School* model entrepreneurship initiatives, "Business Creation" activities and "New Technology Creation" or "New Product Creation" activities emerged as the two main types of practical experiences offered. This was similar to the findings from the *Business School* model's initiatives. However, unlike the *Business School* model, there were differences across the initiatives in the institutions of the five countries.

The findings revealed that U.S. *Engineering School* model initiatives primarily offered opportunities for students to create new technologies or new products. There were initiatives where practical experiences were provided for students to identify the needs of customers or society at large, generate technical solutions which also included the development of ideas for new technologies/products, the design of new technologies/products, and the development and creation of prototypes for new technologies/products and business plans for these technologies/products. The activities also provided experiences where students learned how to take their new technologies or products to market, which included the handling of patent and commercialisation issues, the pitch of these technologies and products to potential investors, and the eventual launch of these technologies/product into the market. U.S. *Engineering School* model initiatives also commonly offered “Business Creation” activities, where initiatives provided opportunities for students to work on ideas for new business ventures, and create and develop business plans for these ventures. There were also opportunities for students to launch their new ventures and pitch their business ideas to potential new investors.

Like the U.S. initiatives, the findings showed that New Zealand *Engineering School* model initiatives primarily offered “New Technology Creation” or “New Product Creation” activities, and then “Business Creation” activities. The findings also revealed that Australian, Canadian and U.K. *Engineering School* model initiatives primarily offered practical experiences in business creation, with experiences in new technology or new product creation also offered in several initiatives. The findings also revealed that the initiatives in the five countries offered additional entrepreneurial experiential learning activities, as shown in Table 27.

Table 27: *Engineering School* model entrepreneurship initiative co-curricular and extra-curricular activities offered to engineering undergraduates in Australia, Canada, New Zealand, the United Kingdom, and the United States

Examples of *Engineering School* model entrepreneurship initiative co-curricular and extra-curricular activities	
Country	**Co-curricular/Extra-curricular activity**
Australia	Business creation activities
	New technology/new product creation activities
	Participation in interdisciplinary team projects for real-world clients
	Preparation of innovation reports
	Generation of solutions to business problems
	Undertaking of industry consulting projects for real-world clients and organisations (which included the generation of solutions to business problems)
	Work experience either from internships at existing companies or simulated workplace contexts
	Development of business concepts in real-world environments
Canada	Business creation activities
	New technology/new product creation activities
	Work experience in established companies through internships and co-op placements
	Participation in design projects
	Participation in entrepreneurship clubs, societies, and organisations
	Participation in entrepreneurship competitions and challenges
	Networking opportunities with other individuals who have entrepreneurial interests
	Opportunities to be mentored by individuals with entrepreneurial experience
New Zealand	New technology/new product creation activities
	Business creation activities
	Working on industry and company-issued projects and pitching ideas
	Working on innovation projects
	Development of social enterprise business concepts
	Work experience in established companies through internships and job placements
	Participation in entrepreneurship competitions and challenges, boot-camps, conferences, lectures, workshops, and seminars
	Construction and development of entrepreneurial communities
	Networking opportunities with other individuals who have entrepreneurial interests
	Opportunities to be mentored by individuals with entrepreneurial experience
The United Kingdom	Business creation activities
	New technology/new product creation activities
	Work experience in established companies through internships and job placements
	Participation in entrepreneurship competitions and challenges, boot-camps, conferences, lectures, workshops, and seminars
	Participation in entrepreneurship clubs, societies, and organisations
	Networking opportunities with other individuals who have entrepreneurial interests
	Opportunities to be mentored by individuals with entrepreneurial experience

The United States	New technology/new product creation activities
	Business creation activities
	Identification, evaluation, assessment, and development of potential opportunities
	Work experience in established companies through internships and job placements
	Participation in interdisciplinary team projects for real-world clients
	Participation in real-world design projects
	Community engagement projects where students work with local communities to generate social change
	Acting in consultant roles for small businesses or start-ups
	Development of business models, solutions, strategies, and proposals
	Participation in entrepreneurship clubs, societies, and organisations
	Participation in entrepreneurship competitions and challenges, boot-camps, conferences, lectures, workshops, and seminars
	Networking opportunities with other individuals who have entrepreneurial interests
	Opportunities to be mentored by individuals with entrepreneurial experience

As shown in Table 27, the entrepreneurial experiential learning activities offered in *Engineering School* model initiatives were similar to those in the *Business School* model initiatives. First, several of the same activities were offered across the five countries. These activities included, for example, the opportunity to gain entrepreneurial work experience, and the opportunity to work on industry-based projects. Second, there were similarities to the types of activities offered in *Business School* model entrepreneurship initiatives – for example, networking and mentoring opportunities, development of solutions to business problems, work experience, participation in entrepreneurship competitions, and participation in entrepreneurship clubs and societies. Overall, the findings showed that there were no significant differences in the types of practical entrepreneurial experiences offered amongst institutions following the *Engineering School* model in each of the five countries.

6.4.9: The entrepreneurial competencies emphasised in *Engineering School* model entrepreneurship initiatives

The online questionnaire sent to engineering school administrators provided a list of the 13 Morris et al. (2013b) competencies and then asked respondents to state which of the competencies were emphasised in their entrepreneurship initiatives. In responding, administrators had to state where the level of emphasis lay on the following five-point Likert scale which ranged from '*No emphasis*', '*Some emphasis*', '*Moderate emphasis*', '*Major emphasis*', and '*Significant emphasis*'.

From the 36 administrators whose initiatives followed the *Engineering School* model, the findings first revealed that the 13 Morris et al. (2013b) competencies were emphasised at different levels, and these 13 competencies were either majorly or significantly emphasised in *Engineering School* model entrepreneurship initiatives, as presented in Table 28.

Table 28: The entrepreneurial competencies significantly or majorly emphasised in *Engineering School* model entrepreneurship initiatives for engineering undergraduates

The entrepreneurial competencies significantly and majorly emphasised in *Engineering School* model entrepreneurship initiatives [N = 36]	
Entrepreneurial competency	**% of respondents**
Value Creation	67
Creative Problem Solving	58
Conveying a compelling vision	58
Tenacity or Perseverance	56
Maintain Focus yet adapt	53
Resilience	53
Building and using networks	53
Self-Efficacy	50
Resource Leveraging	47
Opportunity Assessment	44
Guerrilla Skills	39
Opportunity Recognition	36
Risk Management	25

*competencies are listed from the competency that has been significantly/majorly emphasised by the greatest number of respondents to the competency that has been significantly/majorly emphasised by the least number of respondents

As shown in Table 28, 8 of the 13 competencies were either significantly or majorly emphasised by more than 50% of the respondents, with *Value Creation* being the only competency emphasised by more than 60% of the respondents. This showed that *Engineering School* model entrepreneurship initiatives, based on the respondent data, focused more on the creation of new products and services that generate an economic profit and create value for the end-user. On the opposite end of the spectrum, *Risk Management* was the only competency to be either significantly or majorly emphasised by less than 30% of the respondents. This respondent data therefore showed that less emphasis is placed on the prevention of risk and how to minimise the effects which potentially could occur.

Overall, all competencies were emphasised at varying levels. Like the *Business School* model's initiatives, the findings showed that there were differences within each of the 36 initiatives regarding which of the 13 competencies were majorly or significantly emphasised. Despite this, the general view was that more emphasis was placed on some of the 13 competencies, which suggested that these competencies were considered more valuable for students of the initiatives.

6.4.10: The opportunities experienced in *Engineering School* model entrepreneurship initiatives

As discussed in section 5.9, 10 opportunities were offered in *Engineering School* model initiatives for engineering undergraduates to gain entrepreneurial experience. The online questionnaire sent to engineering school administrators allowed respondents to identify the opportunities their initiatives provided to their students.

The findings revealed that within the 36 initiatives that data was available for, the 10 opportunities were offered. These results are presented in Table 29.

Table 29: What engineering undergraduates experience in *Engineering School* model entrepreneurship initiatives for engineering undergraduates

What engineering undergraduates experience in *Engineering School* model entrepreneurship initiatives [N = 36]	
What engineering undergraduates experience	**% of respondents**
Take an entrepreneurship course within the Faculty/School of Engineering	83
Develop a product or technology for a real client/customer	78
Give an "elevator pitch" or presentation to a panel of judges about a product or business idea	75
Write a business plan	75
Participate in an entrepreneurship-related competition	75
Be involved in entrepreneurship- or business-related student organisations	69
Participate in entrepreneurship-related workshops	69
Intern or work for an entrepreneurial or start-up company	67
Conduct market research and analysis for a new product or technology	64
Be involved in patenting a technology or protecting intellectual property	50

Unsurprisingly, the majority of respondents whose initiatives followed the *Engineering School* model stated that opportunities for students to take entrepreneurship courses in the engineering school were provided. Like the findings from the *Business School* model's initiatives, a high percentage of respondents additionally stated that they provided opportunities for their students to develop new products and technologies, write business plans, and participate in entrepreneurship-related competitions. These findings suggested that engineering schools not only provided their students with opportunities for entrepreneurial learning, but they also trained them to develop new technologies and products, write business plans for these new technologies and products, and encouraged students to participate in competitions where they could pitch their ideas to entrepreneurship experts. An interesting finding was that the smallest percentage of respondents stated that their initiatives provided opportunities for student involvement of patenting and the protection of intellectual property. This opportunity was expected to be offered by a greater percentage of the respondents given that students were primarily trained to develop new products and new technologies.

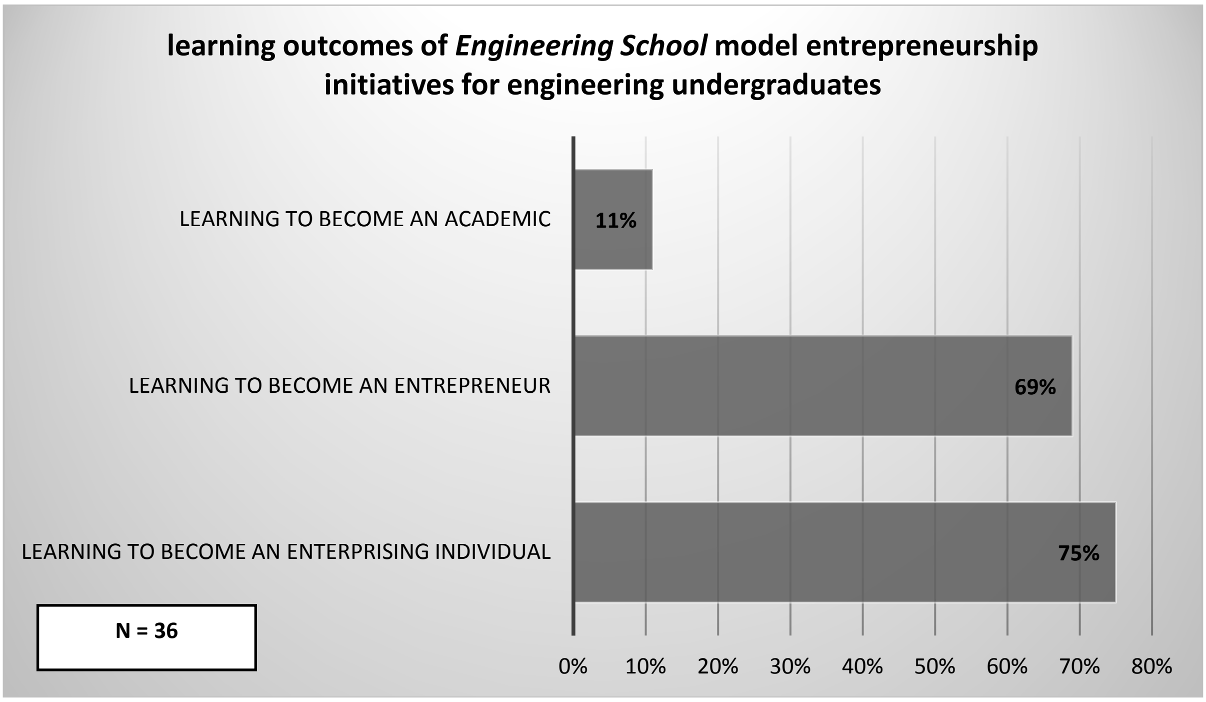
Overall, the findings showed that *Engineering School* model initiatives primarily provided students with opportunities to move their ideas from concept to reality. Students were able to develop their ideas and generate new products and technologies, which could be presented to potential clients with the necessary resources, who in turn continue with the commercialisation process and turn the students' ideas into a market reality.

6.4.11: The outcomes of *Engineering School* model entrepreneurship initiatives

The online questionnaire asked engineering school administrators two questions to determine the outcomes of *Engineering School* model initiatives. First, engineering school administrators were asked to state whether their entrepreneurship initiatives trained their students to become enterprising individuals, entrepreneurs, and/or academics. Second, engineering school administrators were asked about which entrepreneurial-based careers their initiatives prepared their students to undertake.

The findings first revealed that, unlike *Business School* model initiatives, *Engineering School* model initiatives had three learning outcomes. As presented in Figure 32, these initiatives prepared their students to become enterprising individuals, entrepreneurs, and entrepreneurship academics.

Figure 32: The outcomes of *Engineering School* model entrepreneurship initiatives for engineering undergraduates



The primary outcome of the 36 *Engineering School* model initiatives was for students to become enterprising individuals, where, armed with entrepreneurial mindsets, they develop entrepreneurial personas. The students in some initiatives were also educated to become entrepreneurs where they could, for example, start their own businesses, or entrepreneurship academics and carry out entrepreneurial research. This was in line with what engineering undergraduates mainly experience in the initiatives, as identified in section 5.10, where students develop new products, write business plans, and give elevator pitches to experts. Essentially, they think with an entrepreneurial frame of mind and act in entrepreneurial manners.

Next, the review of the data collected from the 36 administrators revealed that *Engineering School* model initiatives also prepared students for the same entrepreneurial careers as *Business School* model entrepreneurship initiatives. This is shown in Table 30.

Table 30: What engineering undergraduates are prepared to do after participation in *Engineering School* model entrepreneurship initiatives

What engineering undergraduates are prepared to do after participation in *Engineering School* model entrepreneurship initiatives [N = 36]	
What engineering undergraduates are prepared to do	**% of respondents**
Start their own business or be self-employed	75
Work for a small business or start-up company	75
Work for a medium- or large-size business	75
Attend graduate/professional school	67
Work for a social enterprise	58
Work for a non-profit organisation	53
Consider an option of their choice	3

As shown in Table 30, students were primarily prepared to either be self-employed or work for existing companies. This suggested that the initiatives prepared students to make a positive impact on society. This, as seen, was done either through income generated via careers in profit-making ventures, or through the launch of ventures which lead to the creation of employment, the generation of income, and contribution to the overall success of the economy. Like the *Business School* model, these findings also showed less emphasis being placed on the preparation of students to work for organisations where the primary goal was not to generate income, with this lower level of emphasis potentially being due to the need for entrepreneurial engineers and the role that they play in the direct economic development of societies through the generation of income and profits. However, in contrast to the *Business School* model, more than 50% of respondents stated that they prepared students to undertake careers in the social and not-for-profit sectors.

Overall, based on the 36 entrepreneurship initiatives, the available data showed that *Engineering School* model entrepreneurship initiatives educated their engineering undergraduates to become enterprising individuals, entrepreneurs, or entrepreneurship academics. In these initiatives, students were also primarily prepared to either start their own businesses or work for existing companies of various sizes.

6.5: The EEE Typology Model 3: The *Multi-School* Model

The *Multi-School* model, as explained in section 6.2., was only present in the United States. The description of this model is divided into 11 sections, the first 4 of which are representative of the characteristics identified in the Standish-Kuon and Rice (2002) typology description, and the remaining 7 presenting additional findings from this research study.

6.5.1: The schools responsible for the creation and development, and the home base, of *Multi-School* model entrepreneurship initiatives

The *Multi-School* model, as defined in the Standish-Kuon and Rice (2002), consisted of initiatives resulting from a partnership among the Schools of Business and Engineering, and one or more technical schools, which were housed either within the business or engineering schools. In order to determine the initiatives that followed the *Multi-School* model, initiative descriptions on institutions' webpages were reviewed to determine the schools responsible for the initiatives and the schools where the initiatives were housed.

First, the findings revealed that both the business and engineering schools were still involved in the creation and development of *Multi-School* model entrepreneurship initiatives. This was the case in 26 of the 28 initiatives. However there was one initiative which excluded the business school and another which excluded the engineering school. Second, the findings also revealed that the schools involved in *Multi-School* model partnerships have moved beyond just technical schools. A greater number of schools were seen in these partnerships – including the Schools of Law, Arts and Sciences, Journalism, Architecture, Education, and Agriculture.

The findings further revealed that initiatives were housed in locations other than just the business and engineering schools. Despite the involvement of a number of different schools in *Multi-School* model partnerships, the findings showed that these initiatives were primarily housed in the business school, which was seen in 54% of the 28 initiatives. In addition, 14% of the initiatives were based in the School of Arts and Sciences, 11% were housed in a freestanding entrepreneurship school, and 11% equally housed in each member school in the partnership. The final initiatives were housed in the engineering school and other schools, including, for example, the Schools of Arts and Sciences, Visual and Performing Arts, or Business.

Overall, as identified in the Standish-Kuon and Rice (2002) study, the findings showed that both the business and engineering schools were still involved in the creation and development of *Multi-School* model initiatives. The findings also showed that additional schools, beyond the technical schools identified in the Standish-Kuon and Rice (2002) study, were also involved in *Multi-School* partnerships. In addition, the findings showed that *Multi-School* model initiatives were primarily housed in the business school, as well as housed in a number of different locations.

6.5.2: The curriculum used in *Multi-School* model entrepreneurship initiatives

In the Standish-Kuon and Rice (2002), the *Multi-School* model initiatives were identified as using a technological entrepreneurship curriculum developed by the business school, engineering school, and the technical schools involved in the partnership. Entrepreneurship initiatives for engineering undergraduates use business-focused (a focus on the creation and running of new business enterprises), technologically-focused (a focus on the creation of new technologies and products that address societal needs), and entrepreneurship-focused (a focus on the acquisition of knowledge in entrepreneurship and what it entails) curriculum types. The descriptions of each of the three curriculum types were compared to initiative and course descriptions on the institutions' webpages in order to determine the curriculum used in *Multi-School* model initiatives.

The findings revealed that *Multi-School* model initiatives mainly used combinations of the three curriculum types. The primary curriculum type seen in these initiatives was business-, technologically-, and entrepreneurship-focused, as used in 54% of the initiatives. The findings also showed that 18% used a business- and technologically-focused curriculum, another 18% used a business- and entrepreneurship-focused curriculum, and the remaining 10% used a business-focused curriculum.

Overall, the findings showed that like the *Business School* and *Engineering School* model initiatives, *Multi-School* model initiatives do not have a specific curriculum type. This supports the view that entrepreneurship initiatives that belong to a specific model are not required to have the same focus, which allows a specific model's initiatives to be distinguished from each other.

6.5.3: Target students of *Multi-School* model entrepreneurship initiatives

In the Standish-Kuon and Rice (2002) study, the target group for *Multi-School* model initiatives was students from each of the schools responsible for the creation and development of initiatives. Entrepreneurship initiatives on institutions' webpages were reviewed in order to determine the target students of *Multi-School* initiatives in this research study.

Unlike the *Multi-School* initiatives described in the Standish-Kuon and Rice (2002) study, the findings revealed that the initiatives examined were primarily designed for all undergraduate students at the institution, regardless of the major followed. The other initiatives were designed either for non-business students or students belonging to the partnership member schools.

The findings overall showed that similar to the *Business School* model's initiatives, *Multi-School* model initiatives were designed to create groups of students from a variety of educational disciplines. As a result, engineering undergraduates work with students following a number of different degrees, thereby simulating multi-disciplinary environments and teamwork. This ultimately prepares engineering undergraduates to face the new engineering arena, which requires a multi-disciplinary, teamwork approach.

6.5.4: The locations where the courses in *Multi-School* model entrepreneurship initiatives are taught and the faculty responsible for the teaching of entrepreneurship

Standish-Kuon and Rice (2002) stated that the entrepreneurship courses in *Multi-School* model initiatives were taught in either the engineering or business schools, implying that courses were taught by academics from either school. To identify where courses were taught in the *Multi-School* initiatives examined in this study, and which faculty members taught these courses, course listings were first located on institutions' webpages in order to determine which schools offered the courses. Next, the webpages of the faculty members were visited to determine which schools they were associated with. Finally, the online questionnaire sent to engineering school administrators asked respondents whether their courses were taught by Engineering Academics, Business Academics, Engineering Graduate Students, Business Graduate Students, Practicing or Experienced Entrepreneurs, or another group.

First, the findings revealed the presence of entrepreneurship courses in a number of different locations, as shown in Table 31.

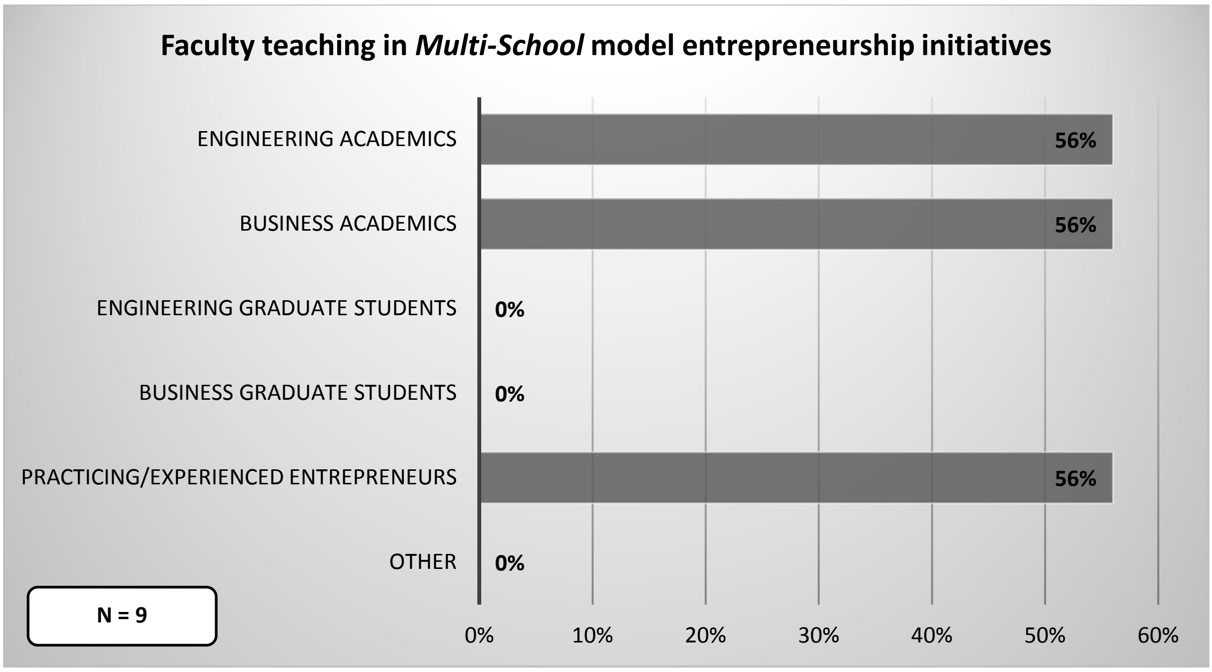
Table 31: The location of entrepreneurship courses in *Multi-School* model entrepreneurship initiatives

The location of entrepreneurship courses in *Multi-School* model entrepreneurship initiatives [N = 28]	
Location	**% of initiatives**
The schools involved in the partnership	46
Business school	20
Business and Engineering schools	7
Arts & Sciences school	7
Engineering school	4
Business, Engineering, and Arts & Sciences schools	4
Freestanding entrepreneurship school	4
Business, Engineering, and Entrepreneurship schools	4
International location	4

The entrepreneurship courses of the 28 initiatives were primarily taught in the partnership's member schools. This showed that each of the members equally shared in the teaching responsibilities. The findings also showed that the business and engineering schools were highly involved in delivery of entrepreneurship courses.

The involvement of different schools in the partnership implied that the teaching faculty used in the entrepreneurship initiatives came from a number of different schools. For each initiative, the faculty involved potentially came from the schools that were responsible for its administration. However, given that the business and engineering schools were primarily involved in the development of initiatives and the delivery of courses, there was a possibility that faculty from both of these schools mainly taught the courses. This idea was confirmed by the findings shown in Figure 33, based on the 9 initiatives that questionnaire data was available for.

Figure 33: The types of faculty teaching courses in Multi-School model entrepreneurship initiatives



As presented in Figure 33, engineering academics, business academics, and practising or experienced entrepreneurship were responsible for the teaching of the courses in the 9 *Multi-School* model initiatives.

Overall, the findings echoed the views expressed in the case of the *Engineering School* model's initiatives – courses do not have to be located in one specific location in order for an initiative to be categorised as belonging to the *Multi-School* model. Furthermore, although the different schools in the partnership shared the teaching responsibilities, the teaching faculty used primarily came from the business and engineering schools, or external to the institution in the form of experienced entrepreneurs. Like the *Business School* and *Engineering School* models, the use of academics and practicing entrepreneurs for teaching suggested that it was important for students to learn about entrepreneurship and how to apply entrepreneurial knowledge and skills in practical settings.

6.5.5: The motivating factors behind the creation of *Multi-School* model entrepreneurship initiatives

The online questionnaire sent to engineering school administrators asked respondents whose initiatives followed the *Multi-School* model to identify the motivating factors that led to the creation and development of the initiatives. The data collected from the 9 respondents highlighted that two factors were responsible for the creation of these initiatives, as presented in Table 32.

Table 32: The motivating factors behind the establishment of *Multi-School* model entrepreneurship initiatives

The motivating factors behind the establishment of *Multi-School* model entrepreneurship initiatives [N = 9]	
Motivating Factor	**% of respondents**
A desire for active collaboration to occur among the business school, engineering school, and some of the other schools in the institution	89
A desire for active collaboration to occur among the engineering school and some of the other schools in the institution	11

As shown in Table 32, the primary motivating factor behind the creation of *Multi-School* model initiatives was a desire for collaboration among a number of schools at the institution. This could indicate a desire for a multi-disciplinary learning environment and a sharing of knowledge among a variety of educational fields, which could have resulted from a need for engineers to have multidisciplinary personas or the capability to work on teams comprised of individuals from numerous disciplines. As a result, this could indicate a belief that the acquisition of multi-disciplinary personas and the capability to work with people in other disciplines could be achieved from the interaction with others who come from non-engineering backgrounds.

6.5.6: The objectives of *Multi-School* model entrepreneurship initiatives

Entrepreneurship initiatives for engineering undergraduates have four objectives (see section 5.6) aimed at educating “about” and “for” entrepreneurship. The objectives included the provision of an understanding of entrepreneurship, the development of an entrepreneurial mindset, the provision of entrepreneurial knowledge and skills, and the provision of practical entrepreneurial experiences.

Like the *Business School* and *Engineering School* model initiatives, the review of the objectives stated by the 9 administrators whose initiatives followed the *Multi-School* model showed that the initiatives collectively had the four objectives and each *Multi-School* model initiative had no more than one or two of the four objectives. For example, respondents R80 and R88 stated:

Respondent ID	Objective
R80	*"To develop business plans etc."*
R88	*"Build the culture of innovation and open students to the idea of entrepreneurial thinking and entrepreneurship."*

The findings generally showed that entrepreneurship initiatives could belong to the same model despite possessing different objectives. Similar to the two previous models' initiatives, the differences in the objectives demonstrate the different approaches of entrepreneurship education for engineering undergraduates. As a result, based on the findings from the online questionnaire, *Multi-School* model entrepreneurship initiatives are not required to have the same objectives to belong to the same model.

6.5.7: The types of educational programmes offered in *Multi-School* model entrepreneurship initiatives

Entrepreneurship initiatives for engineering students, as discussed in section 5.7, offer five educational programmes including entrepreneurship-based bachelor degree programmes, short entrepreneurship programmes, entrepreneurial experiential or practical learning programmes, individual entrepreneurship courses, and individual entrepreneurial engineering courses and projects. Descriptions of the entrepreneurship initiatives on institutions' webpages were reviewed to determine the educational programmes offered.

The findings revealed that *Multi-School* model entrepreneurship initiatives offered two of the five educational programmes. These initiatives primarily offered short entrepreneurship programmes, consisting of academic minor or certificate programmes in, for example, general entrepreneurship, innovation, technology entrepreneurship, entrepreneurial engineering and venture creation. Some *Multi-School* model initiatives also offered entrepreneurial experiential or practical learning programmes, where students gained hands-on experience in, for example, prototype development and the pitch of these to entrepreneurs and venture capitalists, the development of new products from concept to market entry, and operation in entrepreneurial ventures or start-ups.

Overall, the programmes offered in *Multi-School* model entrepreneurship initiatives were either short programmes where students gained an additional qualification to enhance their degrees, or practical programmes where students learned how to undertake specific entrepreneurial activities. Unlike the initiatives of the *Business School* and *Engineering School* models, no bachelor or undergraduate degree programmes were offered. This suggested that the aim of the *Multi-School* model entrepreneurship initiatives was to enhance the abilities of students by adding entrepreneurship to their major fields of interest, in lieu of pursuing an entrepreneurially-focused undergraduate degree; as well as stimulate collaboration among a number of academic disciplines.

6.5.8: The practical experiences offered in *Multi-School* model entrepreneurship initiatives

In order to determine the co-curricular activities (for-credit practical entrepreneurship activities) and extra-curricular activities (not-for-credit practical entrepreneurship activities) offered in *Multi-School* model initiatives, institutions' webpage descriptions of the initiatives and the courses offered were reviewed.

The findings showed that "Business Creation" activities were the primary practical experiences offered in *Multi-School* model entrepreneurship initiatives. Several of the initiatives focused on, for example, the creation and development of business plans, and the proposal and launch of new business ventures. Several initiatives also offered "New Technology Creation" or "New Product Creation" activities, where the initiatives focused on, for example, the development of prototypes, the development of new technologies or products, and the preparation of these technologies and products for market launch.

In addition to the "Business Creation" and "New Technology Creation"/"New Product Creation" activities primarily offered, the findings showed that initiatives also offered other types of practical entrepreneurial experiences, including:

- evaluating and assessing potential business opportunities;
- undertaking internships and job placements at existing companies and organisations;
- acting as consultants for existing companies and organisations;
- developing business models;
- creating social enterprises;
- participating in entrepreneurship competitions and challenges;
- participating in entrepreneurship boot camps and workshops;
- networking with others who possess entrepreneurial interests; and
- being mentored by individuals who had experience in entrepreneurship.

Overall, the findings revealed that *Multi-School* model entrepreneurship initiatives offered the same co-curricular and extra-curricular activities as the initiatives offered in the *Business School* and *Engineering School* models. In comparing the three models, the result showed no differences amongst the models with regards to the types of practical experiences offered. This suggested that if students had participated either in *Multi-School* model entrepreneurship initiatives or initiatives belonging to the two previous models, they would essentially gain the same practical experience in entrepreneurship.

6.5.9: The entrepreneurial competencies emphasised in *Multi-School* model entrepreneurship initiatives

The engineering school administrators who responded to the questionnaire were asked which of the 13 Morris et al. (2013b) competencies listed in 5.5 they emphasised in their initiatives. To identify the initiatives, the respondents were asked to indicate the emphasis on the following five-point Likert scale ranging from '*No emphasis'*, '*Some emphasis'*, '*Moderate emphasis'*, '*Major emphasis'*, and '*Significant emphasis*'.

Like the initiatives of the *Engineering School* model, the data collected from the 9 initiatives following the *Multi-School* model first showed that the 13 of the Morris et al. (2013b) competencies were emphasised at some level within the initiatives, and these 13 competencies were either majorly or significantly emphasised. This is presented in Table 33.

Table 33: The entrepreneurial competencies significantly or majorly emphasised in *Multi-School* model entrepreneurship initiatives

The entrepreneurial competencies significantly and majorly emphasised in *Multi-School* model entrepreneurship initiatives [N = 9]	
Entrepreneurial competency	**% of respondents**
Opportunity Assessment	67
Creative Problem Solving	67
Risk Management	56
Conveying a compelling vision	56
Tenacity or Perseverance	56
Value Creation	56
Self-Efficacy	56
Building and using networks	44
Opportunity Recognition	33
Resource Leveraging	33
Guerrilla Skills	33
Maintain Focus yet adapt	33
Resilience	33

*competencies are listed from the competency that has been significantly/majorly emphasised by the greatest number of respondents to the competency that has been significantly/majorly emphasised by the least number of respondents

Table 33 showed that 7 of the 13 competencies were either majorly or significantly emphasised by more than 50% of the respondents whose initiatives followed the *Multi-School* model. Two of the competencies, *Opportunity Assessment* and *Creative Problem Solving*, the latter of which was emphasised by the majority of respondents following the *Business School* model, were the two competencies either strongly or majorly emphasised by the majority of *Multi-School* model respondents.

The findings generally showed that although students require the entrepreneurship competencies in order to be and act in entrepreneurial manners, they must primarily be able to determine the viability of potential opportunities and bring resources together in ways that allow for the opportunities to be taken advantage of and new outputs to be produced. Like the two previous models' initiatives, the findings additionally showed that each initiative majorly or significantly emphasised different competencies. However, the findings showed that collectively, more value was placed on some competencies as opposed to others.

6.5.10: The opportunities experienced in *Multi-School* model entrepreneurship initiatives

On the online questionnaire, engineering school administrators were asked to state the opportunities offered in their initiatives for students to gain hands-on experience in entrepreneurship. A review of the data collected from the 9 administrators whose initiatives followed the *Multi-School* model showed that the 10 opportunities presented in section 5.9 were offered. These findings were the same as the findings seen in *Business School* and *Engineering School* model initiatives. The findings from *Multi-School* model initiatives are presented in Table 34.

Table 34: The opportunities engineering undergraduates experience in *Multi-School* model entrepreneurship initiatives for engineering undergraduates

The opportunities engineering undergraduates experience in *Multi-School* model entrepreneurship initiatives [N = 9]	
What engineering undergraduates experience	**% of respondents**
Intern or work for an entrepreneurial or start-up company	67
Develop a product or technology for a real client/customer	67
Write a business plan	67
Take an entrepreneurship course within the Faculty/School of Engineering	56
Be involved in patenting a technology or protecting intellectual property	56
Be involved in entrepreneurship- or business-related student organisations	56
Give an “elevator pitch” or presentation to a panel of judges about a product or business idea	44
Participate in an entrepreneurship-related competition	44
Conduct market research and analysis for a new product or technology	22
Participate in entrepreneurship-related workshops	22

Table 34 showed that the majority of the 9 *Multi-School* model initiatives provided opportunities for students to gain practical entrepreneurial experience by working for entrepreneurial companies, developing new products and technologies, and writing business plans. The smallest percentage of respondents, on the other hand, provided students with opportunities to either participate in entrepreneurship-related workshops or conduct the market research and analysis necessary for the new technologies or products.

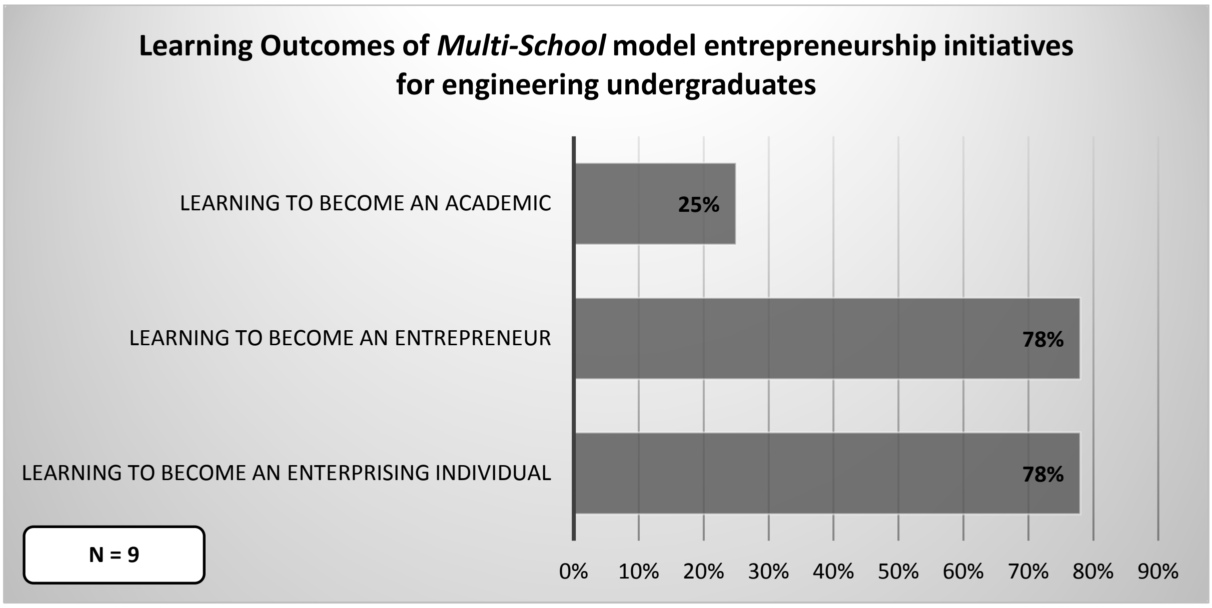
Overall, these findings demonstrated a similarity to the *Business School* and *Engineering School* models, where a high percentage of the respondents stated that their students developed new products and technologies and wrote business plans. An interesting finding was the higher offering of opportunities to develop new products and technologies in comparison to the relatively low offering of opportunities to perform the background work behind the development of new products and technologies. This suggested that in the 9 initiatives following the *Multi-School* model, more emphasis was placed on technology/product creation as opposed to the research and analysis that lead to the actual creation. In general, the findings showed that *Multi-School* model entrepreneurship initiatives primarily offer similar opportunities to those of the entrepreneurship initiatives of the *Business School* and *Engineering School* models.

6.5.11: The outcomes of *Multi-School* model entrepreneurship initiatives

Two sets of outcomes for *Multi-School* model initiatives were determined in this research. In the online questionnaire, engineering school administrators were asked whether students participating in their entrepreneurship initiatives were educated to become enterprising individuals, entrepreneurs, or entrepreneurship academics. These administrators were also asked to state the entrepreneurial-based careers their students were prepared to undertake completion of their education.

Like the *Engineering School* model's initiatives, the initiatives following the *Multi-School* model had three learning outcomes, as presented in Figure 34.

Figure 34: The outcomes of *Multi-School* models entrepreneurship initiatives for engineering undergraduates



The two outcomes of becoming an enterprising individual and becoming an entrepreneur were equally important in the 9 *Multi-School* model initiatives that data was available for. These findings suggested that *Multi-School* model initiatives primarily prepared students to follow the path to becoming entrepreneurial, whether it is by starting businesses or acting in other entrepreneurial ways. This showed that the initiatives prepared students to undertake an entrepreneurial career of their choice through the provision of the necessary tools.

The data collected from the 9 administrators whose initiatives follow the *Multi-School* model revealed that the entrepreneurial careers students were prepared for were like those of the *Business School* and *Engineering School* models' initiatives. This is presented in Table 35.

Table 35: What engineering undergraduates are prepared to do after participation in *Multi-School* model entrepreneurship initiatives

What engineering undergraduates are prepared to do after participation in *Multi-School* model entrepreneurship initiatives [N = 9]	
What engineering undergraduates are prepared to do	**% of respondents**
Start their own business or be self-employed	56
Work for a small business or start-up company	44
Attend graduate/professional school	44
Work for a medium- or large-size business	33
Work for a social enterprise	33
Work for a non-profit organisation	33

Like the *Business School* and *Engineering School* models, the majority of respondents stated that they prepared their students to launch their own ventures. This showed that students were mainly prepared for careers which enabled them to make direct economic contributions to society. Furthermore, like the previous models, fewer respondents stated that their initiatives prepared students to have careers in organisations where the focus was not primarily on the generation of incomes and profits, i.e. social enterprises and non-profit organisations.

Overall, the data collected from the 9 entrepreneurship initiatives following the *Multi-School* model showed that the outcomes of the initiatives was for students to become enterprising individuals, entrepreneurs, or entrepreneurship academics. Although these initiatives prepared their students for six careers where their entrepreneurial knowledge and skills could be implemented, students were mainly prepared to become self-employed and launch their own ventures.

6.6: The EEE Typology Model 4: The *External Partnership* Model

The *External Partnership* model was the first of the two additional models developed from this research to extend the typology developed in the Standish-Kuon and Rice (2002) study. This model was predominantly used in the United States, although one example was found in Canada. To describe the *External Partnership* model, this description is divided into 11 sections. The first 4 describe the distinguishing characteristics of the model using the dimensions used in the Standish-Kuon and Rice (2002) study, with the remaining 7 sections detailing the distinguishing characteristics of the model using the additional criteria adopted in this research.

6.6.1: The schools responsible for the creation and development, and the home base, of *External Partnership* model entrepreneurship initiatives

The criteria used to identify models involved a review of initiative descriptions present on the institutions' webpages, and an analysis of data regarding the schools involved in the initiatives and the locations of the initiatives. The entrepreneurship initiatives that could not be classified as either following the *Business School*, *Engineering School*, or *Multi-School* models were collected and similarities were drawn.

From this process, the findings showed that initiatives classified as *External Partnership* model initiatives involved not only schools at the home institution but also external entities. The Canadian *External Partnership* model initiative was developed by the engineering and business schools of the institution in collaboration with external individuals and organisations. The U.S.-based initiatives were also developed in collaboration with external partners. The partnerships included either the engineering school, or both the engineering and business schools. Of the 34 U.S. initiatives, 88% were developed in collaboration with networks, 9% were developed from the sponsorship by local organisations, and 3% were developed in collaboration with other tertiary-level institutions. This collaboration with external partners is what differentiated the *External Partnership* model from the *Engineering School* model, where, in the case of the *Engineering School* model, initiatives were not developed in collaboration with entities external to the institution.

The findings additionally revealed that the Canadian initiative was housed in both the engineering and business schools. The U.S. initiatives, on the other hand, were primarily housed in the engineering school, as seen in 77% of the initiatives. Furthermore, 12% of the U.S. initiatives were housed in both the engineering and business schools, 9% were housed solely in the business school, and the final initiative was housed in the School of Arts and Sciences.

Overall, the findings showed that initiatives categorised as following the *External Partnership* model resulted from partnerships involving external networks, organisations, or individuals. Furthermore, the engineering school played a primary role in the creation and development of the initiatives, and was also the main location within which these initiatives were housed. However, in some initiatives, the business school also played a role in both the establishment and housing of the initiatives.

6.6.2: The curriculum used in *External Partnership* model entrepreneurship initiatives

Entrepreneurship initiatives for engineering undergraduates use a curriculum type that is either business-focused, which looks at the creation and running of new business enterprises, technologically-focused, which addresses new technology and new product creation targeted at addressing the needs of society, and entrepreneurship-focused, which is centred on acquiring knowledge about entrepreneurship and the relevant theories and concepts. In order to determine which curriculum types were used in *External Partnership* model initiatives, the descriptions of the entrepreneurship initiatives and individual courses on institutions' webpages were compared to the different curriculum types.

The curriculum used in these initiatives were structured and developed by the schools and the external bodies involved in each of the *External Partnership* model initiatives. The findings showed that the initiatives mainly used combinations of the three curriculum types. The Canadian initiative used a business- and technologically-focused curriculum, which was implemented in a specially designed engineering and business collaborative programme. In the U.S. initiatives, a business- and technologically-focused curriculum was the predominant type used, as seen in 50% of the 34 initiatives, with a technologically-focused curriculum used by 27% of the initiatives. The remaining initiatives used either a business-, technologically- and entrepreneurship-focused curriculum, or a business-focused curriculum.

Overall, the findings showed that the initiatives categorised as *External Partnership* model shared similarities with the initiatives of the previous three models in that there is no one specific curriculum type which can be referred to as an "*External Partnership*" curriculum. Furthermore, the findings showed that the curriculum used in *External Partnership* model initiatives were primarily combinations of the three broad curriculum types, which suggests, that, like the three previous models, initiatives following one model are not necessarily required to have the same focus.

6.6.3: Target students of *External Partnership* model entrepreneurship initiatives

To determine the target students of *External Partnership* initiatives, descriptions of entrepreneurship initiatives on institutions' webpages were reviewed and information on the relevant students of initiatives was collected and grouped. First, the findings revealed that the Canadian initiative was designed specifically for engineering undergraduates majoring in a specific type of engineering as well as business undergraduates majoring in entrepreneurship. Second, the findings revealed that the U.S. initiatives were primarily designed for engineering undergraduates, as seen in 71% of the 34 U.S. initiatives. A further 21% were designed for all undergraduate students. However, there were three exceptions – one was designed for all undergraduate students except those pursuing undergraduate business degrees, another was designed specifically for business and engineering undergraduate students and the third was designed for undergraduates majoring in engineering and computer science.

In addition, these findings showed similarity to the *Engineering School* model, in that the initiatives were mainly focused on educating engineering undergraduates in engineering-only environments, despite the presence of initiatives that involved students from the business school and, in some cases, students from other disciplines. The findings therefore showed that like the *Engineering School* model initiatives, but in contrast to the initiatives following the *Business School* and *Multi-School* models, a different view was taken on the way in which engineering undergraduates experienced entrepreneurship – one where engineering students primarily learned about entrepreneurship by interacting with one another, and having limited interaction with students from other disciplines.

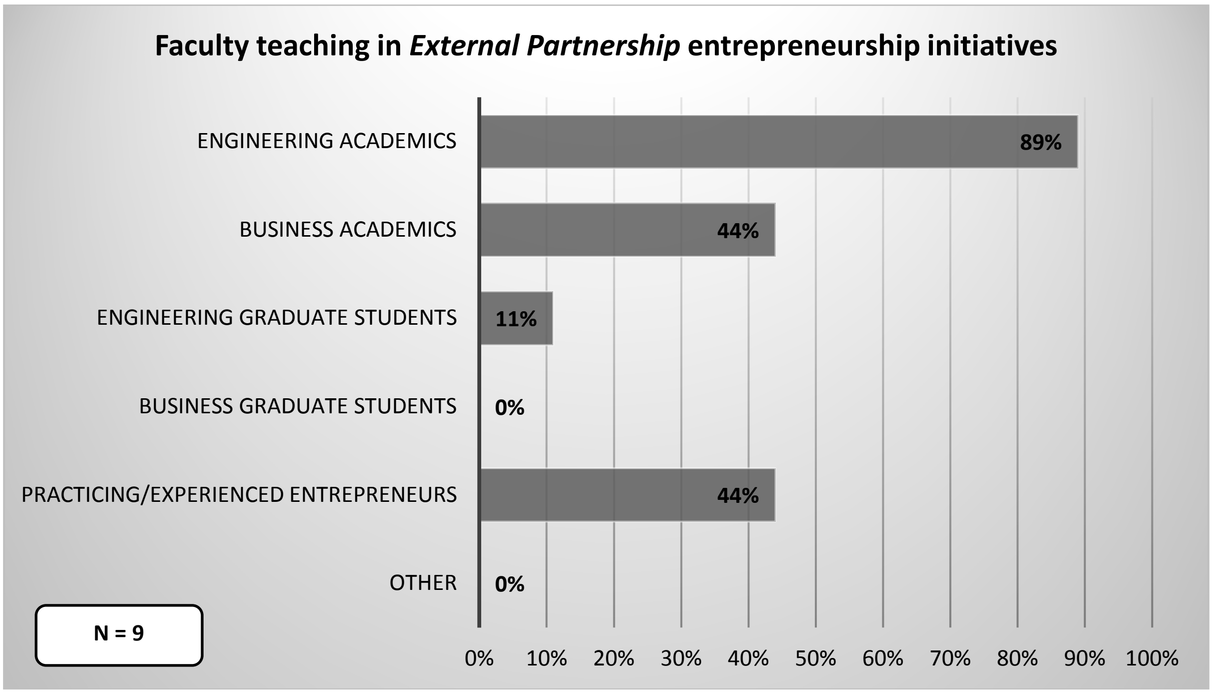
6.6.4: The locations where the courses in *External Partnership* model entrepreneurship initiatives are taught and the faculty responsible for the teaching of entrepreneurship

The identification of the locations from which courses were taught in *External Partnership* model initiatives required a review of the course listings on institutions' webpages to acquire information about the schools responsible for the course offering. Faculty pages on the webpages were then reviewed in order to determine where faculty members were located. In addition, engineering school administrators were asked to state on the online questionnaire whether they used engineering academics, business academics, engineering graduate students, business graduate students, practicing or experienced entrepreneurs, or additional groups to teach the courses.

The study found that the courses of the Canadian initiative were delivered in both the engineering and business schools. In 60% of the U.S. initiatives, the courses were taught solely in the engineering school, while courses in 15% of the initiatives were delivered in the business school, 12% had courses delivered in both the engineering and business schools, and the initiative housed in the School of Arts and Sciences had its courses delivered in the Schools of Business and Arts and Sciences.

The review of the faculty webpages showed that the faculty members teaching entrepreneurship courses were from the engineering and business schools, with faculty members from the arts and sciences school teaching courses in the initiative housed within this school. In addition, the questionnaire data collected from the 9 administrators whose initiatives followed the *External Partnership* model revealed that engineering academics, primarily taught the entrepreneurship courses in these initiatives, as presented in Figure 35.

Figure 35: The types of faculty teaching entrepreneurship courses in *External Partnership* model entrepreneurship initiatives



Like the previous three models, Figure 35 showed that courses in the 9 entrepreneurship initiatives were taught by engineering academics, business academics, and practising or experienced entrepreneurs. The *External Partnership* model was unique in that it was the only model discussed to this point which included graduate students in the teaching of courses.

Overall, the findings revealed that although courses of *External Partnership* model initiatives were primarily delivered in the engineering school, they were also delivered in additional schools. This showed that there was no specific location where entrepreneurship courses had to be delivered in *External Partnership* model entrepreneurship initiatives. Furthermore, the findings showed that academics from the engineering school were primarily responsible for the teaching of courses, although academics from other schools, mainly the business school, shared the teaching responsibilities. Like the previous models, the findings showed that not only did academics teach entrepreneurship, but entrepreneurs external to the institution also contributed to the teaching of entrepreneurial knowledge and experience.

6.6.5: The motivating factors behind the creation of *External Partnership* model entrepreneurship initiatives

Engineering school administrators were asked to identify on the online questionnaire the factors that influenced the creation of entrepreneurship initiatives for engineering undergraduates. From the review of the data collected from the 9 administrators whose initiatives followed the *External Partnership* model, two factors were identified, as shown in Table 36.

Table 36: The motivating factors behind the establishment of *External Partnership* model entrepreneurship initiatives

The motivating factors behind the establishment of *External Partnership* model entrepreneurship initiatives [N = 9]	
Motivating Factor	**% of respondents**
A partnership with the home institution and an external organisation and/or another institution	78
An institution-wide initiative	22

The primary motivating factor identified for the development of the 9 *External Partnership* model entrepreneurship initiatives was a desire for the home institution to collaborate with other partners and academic institutions. The motivating factors for the remaining initiatives were representative of the fact that they were developed by engineering-only institutions using grants and other forms of funding from external organisations they were affiliated with. In contrast to the three previous models, the findings revealed that the entrepreneurship initiatives were developed due to interests that the home institutions had in broadening their relationships with external entities and creating entrepreneurial networks.

Based on the available data, the findings showed that regardless of the type of interaction – either through monetary contributions or the sharing of knowledge – the desire for a relationship with entities external to the home institution is what resulted in the creation of *External Partnership* model initiatives.

6.6.6: The objectives of *External Partnership* model entrepreneurship initiatives

Entrepreneurship initiatives for engineering undergraduates, as discussed in section 5.6, develop entrepreneurial personas within engineering undergraduates by providing students with a general understanding of entrepreneurship, an entrepreneurial mindset, the knowledge and skills required for one to be and act entrepreneurially, and practical entrepreneurial experiences. To determine the objectives of initiatives following the *External Partnership* model, engineering school administrators were asked to state their objectives on the online questionnaire.

Like the initiatives following the first three models, the four objectives were seen in these initiatives, with each initiative having either one or two objectives. For example, respondents R83 and R99 stated:

Respondent ID	**Objective**
R83	*"Train at least 20% of our graduates to be tech entrepreneur employers who will help local tech based economic diversification."*
R99	*"Develop entrepreneurial mindset which students will carry into the workforce."*

The findings generally demonstrated the multi-directional approach of entrepreneurship education for engineering undergraduates seen in the initiatives of the three previous models. As a result, *External Partnership* model initiatives do not necessarily possess the same objectives.

6.6.7: The types of educational programmes offered in *External Partnership* model entrepreneurship initiatives

As discussed in section 5.7, the entrepreneurship initiatives for engineering undergraduates offer any of five different educational programmes: entrepreneurship-based bachelor degree programmes, short entrepreneurship programmes, entrepreneurial experiential or practical learning programmes, individual entrepreneurship courses, and individual entrepreneurial engineering courses and projects. The descriptions of entrepreneurship initiatives on institutions' webpages were reviewed in order to determine the types of programmes that were offered.

The type of programme offered within the Canadian initiative was an entrepreneurial experiential programme, where students first developed a market-inspired technological product, and then pitched for funding in order for it to be launched into the market. In U.S. institutions, on the other hand, all five types of programmes were seen in the initiatives. The findings revealed that the primary educational programme offered was short entrepreneurship programmes in the form of academic minor and certificate programmes. This finding was similar to those of the U.S.-based initiatives of the *Business School*, *Engineering School*, and *Multi-School* models, in which academic minors and certificates were the primary type offered in, for example, engineering entrepreneurship, technology innovation, technology commercialisation, general entrepreneurship, and innovation. The entrepreneurship-based bachelor degrees offered were bachelor degrees that combined engineering and business with the business major being in entrepreneurship. The entrepreneurial experiential programmes included programmes where students gained hands-on experience in, for example, the development of entrepreneurial and business ideas, the design and development of functional prototypes and devices, and solutions to engineering problems. The individual entrepreneurship courses were courses added as electives to engineering degrees; while the individual entrepreneurial engineering courses consisted of engineering courses with integrated entrepreneurial content as well as senior engineering design projects which were focused on product design and the use of technology to solve real-world problems.

Overall, the findings revealed that *External Partnership* model initiatives offered the five educational programmes described in section 5.7, which meant that like the initiatives of the previous models, there is no specific entrepreneurship programme offered by *External Partnership* model initiatives.

6.6.8: The practical experiences offered in *External Partnership* model entrepreneurship initiatives

To determine the practical experiences offered in *External Partnership* model initiatives, a review was conducted on the institutions' webpage descriptions of the initiatives in order to extract the co-curricular activities (for-credit practical entrepreneurship activities) and extra-curricular activities (not-for-credit practical entrepreneurship activities) offered.

The findings revealed that the Canadian initiative focused on "New Technology Creation" or "New Product Creation" activities where, students designed and developed a technological product which was subsequently pitched to investors in order for it to be prepared for market. "New Technology Creation" or "New Product Creation" activities were also the primary type of practical activities offered in U.S.-based initiatives. These activities mainly focused on the development of ideas for new technologies or products, the design of new technologies/products, the writing of business plans to describes these technologies/products, prototype creation, and the pitch of technologies/products to enable market launch. U.S.-based initiatives also offered "Business Creation" activities, where students, for example, derived ideas for new business ventures, wrote business plans to support these new ventures, and also the actual launch of new ventures.

In addition to these two main types of practical activities, other activities were offered in U.S. initiatives which allowed for students to gain practical experience in entrepreneurship. These activities are presented in Table 37.

Table 37: U.S. *External Partnership* model entrepreneurship initiative co-curricular and extra-curricular activities offered to engineering undergraduates

Examples of U.S. *External Partnership* model entrepreneurship initiative co-curricular and extra-curricular activities
New technology/new product creation activities
Business creation activities
Identification and evaluation of opportunities
Work experience in established companies through internships and job placements
Participation in interdisciplinary team projects for real-world clients
Senior Design projects, where students undertake real-world design projects
Creation of social ventures
Solving of real-world engineering problems using entrepreneurial skills
Management and operation of new enterprises
Development of business models
Participation in entrepreneurship clubs, societies, and organisations
Participation in entrepreneurship competitions and challenges, boot-camps, conferences, lectures, workshops, and seminars
Creation of entrepreneurial communities
Networking opportunities with other individuals who have entrepreneurial interests
Opportunities to be mentored by individuals with entrepreneurial experience

The findings generally revealed that "New Technology Creation" or "New Product Creation" activities were the main type offered in *External Partnership* model entrepreneurship initiatives. Despite the primary focus on the creation of new technologies or products, the co- and extra-curricular activities offered through *External Partnership* model initiatives did not significantly differ from the activities offered through the initiatives of the previous three models. The findings therefore show that the types of practical learning opportunities students experience do not widely diverge across the four models discussed to this point.

6.6.9: The entrepreneurial competencies emphasised in *External Partnership* model entrepreneurship initiatives

Engineering school administrators were asked to identify the level of emphasis placed on each of the 13 Morris et al. (2013b) competencies within their entrepreneurship initiatives. Using a five-point Likert scale, respondents had to state whether no emphasis, some emphasis, moderate emphasis, major emphasis, or significant emphasis was placed on each competency in the initiatives. The results of this are shown in Table 38.

Table 38: The entrepreneurial competencies significantly or majorly emphasised in *External Partnership* model entrepreneurship initiatives

The entrepreneurial competencies significantly and majorly emphasised in *External Partnership* model entrepreneurship initiatives [N = 9]	
Entrepreneurial competency	**% of respondents**
Creative Problem Solving	89
Opportunity Recognition	78
Value Creation	78
Conveying a compelling vision	67
Tenacity or Perseverance	67
Self-Efficacy	67
Maintain Focus yet adapt	56
Building and using networks	56
Opportunity Assessment	44
Resilience	44
Resource Leveraging	33
Guerrilla Skills	33
Risk Management	11

*competencies are listed from the competency that has been significantly/majorly emphasised by the greatest number of respondents to the competency that has been significantly/majorly emphasised by the least number of respondents

Based on the data collected from the 9 administrators whose initiatives followed the *External Partnership* model, the findings first revealed that each of the 13 competencies were emphasised in these initiatives. Of the 13 competencies, 7 were either majorly or significantly emphasised by more than 50% of the respondents. In comparison to the

Engineering School model, these seven were also majorly or significantly emphasised by 50% or more of the respondents whose initiatives followed that model. The competency majorly or significantly emphasised by the majority of the respondents was *Creative Problem Solving*, with high percentages majorly or significantly emphasising *Opportunity Recognition* and *Value Creation*. Like the *Engineering School* model, *Risk Management* was the competency majorly or significantly emphasised by the smallest percentage of respondents. For both models this was expected, given that students in initiatives following these models were primarily educated in engineering schools by engineering academics, and traditionally, engineering is risk averse.

Overall, the findings from the 9 administrators showed that within the *External Partnership* model, the primary focus is on the preparation of students to identify opportunities that exist in the market, combine the available resources in new ways that coincide with the opportunity, and then create new products and services that can benefit the end-users, while generating profits for the creator. As shown in Table 38, and as recognised in the findings related to the previous models, although all competencies are emphasised, greater value is placed on some competencies as opposed to others.

6.6.10: The opportunities experienced in *External Partnership* model entrepreneurship initiatives

As discussed in section 5.9, entrepreneurship initiatives for engineering undergraduates offer 10 opportunities for students to gain experience in entrepreneurship. On the online questionnaire sent to engineering school administrators, respondents had to identify which of these 10 opportunities they offered in their initiatives and state any opportunities they additionally offered.

Based on the data collected from the 9 respondents whose initiatives followed the External Partnership model, the 10 opportunities were present in these initiatives, and no further opportunities were identified. This was also the case in the previous models discussed. The findings are shown in Table 39.

Table 39: The opportunities engineering undergraduates experience in *External Partnership* model entrepreneurship initiatives

The opportunities engineering undergraduates experience in *External Partnership* model entrepreneurship initiatives [N = 9]	
What engineering undergraduates experience	**% of respondents**
Give an "elevator pitch" or presentation to a panel of judges about a product or business idea	78
Be involved in entrepreneurship- or business-related student organisations	78
Participate in an entrepreneurship-related competition	78
Participate in entrepreneurship-related workshops	78
Take an entrepreneurship course within the Faculty/School of Engineering	67
Develop a product or technology for a real client/customer	67
Intern or work for an entrepreneurial or start-up company	56
Conduct market research and analysis for a new product or technology	56
Be involved in patenting a technology or protecting intellectual property	56
Write a business plan	44

The findings revealed that most respondents' initiatives focus on presenting ideas to experts, participating in entrepreneurship competitions and workshops, and encouraging students to network with others who possess entrepreneurial interests, and less on, for example, writing business plans for new ideas.

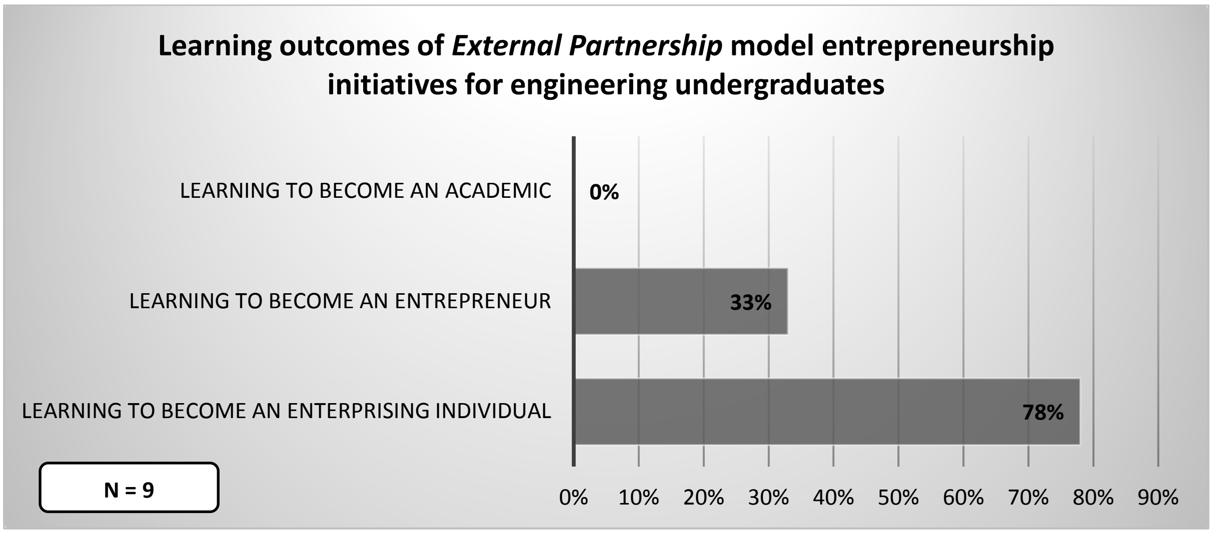
Overall, the findings showed that the *Business School*, *Engineering School*, *Multi-School*, and *External Partnership* models all offer the same opportunities within their initiatives for students to gain experience in entrepreneurship. Despite this, the findings have demonstrated that generally, the initiatives following each of the models differ with regards to the focus of their initiatives. For the *External Partnership* model, these findings suggest greater value is placed on different activities when compared to the previous models.

6.6.11: The outcomes of *External Partnership* model entrepreneurship initiatives

The outcomes of *External Partnership* model initiatives refer to what these initiatives educated students to be and do. On the questionnaire, engineering school administrators were first asked to identify whether students were educated to become enterprising individuals, entrepreneurs, and/or academics, and then asked to identify the careers that their students were prepared to pursue.

First, based on the data collected from the 9 administrators whose initiatives followed the *External Partnership* model, the findings revealed that like the *Business School* model's initiatives, these initiatives had two learning outcomes. This is shown in Figure 36.

Figure 36: The outcomes of *External Partnership* model entrepreneurship initiatives for engineering undergraduates



In comparison to the previous models, where high percentages of the respondents identified both learning to become enterprising individuals and learning to become entrepreneurs as their main outcomes, there was a greater difference between the percentages of respondents whose initiatives followed the *External Partnership* model. As seen in Figure 36, the primary learning outcome of the initiatives was for students to become enterprising individuals, where students develop entrepreneurial mindsets and personas. Although a learning outcome was for students to become entrepreneurs, this was for a significantly smaller percentage in comparison to the percentage stating the primary outcome. Looking at the opportunities the students experience in the initiatives, discussed in section 6.6.10, a direct link can be seen to the goal of developing engineering undergraduates into enterprising individuals through the stimulation of the mindset provided by networking in organisations, receiving feedback and participating in competitions and workshops.

Second, the data from the 9 administrators further showed that the initiatives prepared students to pursue the careers that were also identified in the previous models' initiatives, as shown in Table 40.

Table 40: What engineering undergraduates are prepared to do after participation in *External Partnership* model entrepreneurship initiatives

What engineering undergraduates are prepared to do after participation in *External Partnership* model entrepreneurship initiatives [N = 9]	
What engineering undergraduates are prepared to do	**% of respondents**
Work for a small business or start-up company	89
Start their own business or be self-employed	78
Work for a medium- or large-size business	78
Attend graduate/professional school	78
Work for a social enterprise	56
Work for a non-profit organisation	56

In contrast to the initiatives following the *Business School* and *Multi-School* models, the *External Partnership* model initiatives primarily prepare students to work for small business and start-up companies – a career that initiatives following the *Engineering School* model primarily emphasise. This finding can be linked to the fact that the primary outcome of the initiatives following the *External Partnership* model was for students to become enterprising individuals. This could suggest the enabling of students to act entrepreneurially in existing ventures. The findings also revealed a similarity to the *Business School* model's initiatives, where a significant percentage of initiatives prepared students to attend graduate or professional schools despite becoming an academic not being an outcome of the initiatives. In this case, a similar suggestion could be made where the preparation of students to attend graduate or professional school was to acquire a higher level of education and subsequently enhance employment prospects. In addition, the findings showed that less emphasis was placed on the preparation of students to find careers in social enterprises and not-for-profit organisations, as was the case in the previous models. This suggested that *External Partnership* model initiatives focus primarily on the preparation of students to make direct contributions to the economic performance of a society via the creation of employment opportunities and the generation of income. However, like the *Engineering School* model, an emphasis on careers in the social sector was stated by more than 50% of the respondents.

Overall, the findings showed that the outcomes of *External Partnership* model entrepreneurship initiatives were mainly for students to become enterprising individuals, and to a lesser degree, entrepreneurs. Furthermore, the initiatives prepared students for the same careers as the initiatives of the *Business School*, *Engineering School*, and *Multi-School* models; however, they were mainly prepared to undertake work in small business enterprises or start-up companies.

6.7: The EEE Typology Model 5: The *Institution* Model

The *Institution* model was the second additional model generated in this research. This model was present in three of the five countries: Australia, the United Kingdom, and the United States. The description of this model is again separated into 11 sections, with the first 4 presenting findings based on the characteristics identified in the Standish-Kuon and Rice (2002) study, and the remaining 7 detailing the distinguishing characteristics of the model using the additional criteria adopted in this research.

6.7.1: The schools responsible for the creation and development, and the home base, of *Institution* model entrepreneurship initiatives

To determine the schools involved in the creation and development of initiatives as well as the home bases of the initiatives, a review was conducted of initiative descriptions on institutions' webpages. As in the case of the *External Partnership* model's initiatives, the initiatives not meeting the criteria of the *Business School*, *Engineering School*, or *Multi-School* models were separated and comparisons were made in order to draw the similarities.

This classification process found a number of initiatives following a model which was subsequently named the *Institution* model. This model was predominantly seen in U.S. institutions, with a total of 30 initiatives identified. The findings also showed the presence of 2 Australian and 3 U.K. *Institution* model initiatives. In all of the initiatives reviewed, the findings showed that these initiatives were developed in its entirety by the institution within which it was based, and not by a number of individual schools. However, the findings suggested that all the schools within the institution collaborated in order to develop the initiatives.

The findings also revealed that these initiatives were predominantly based in freestanding entrepreneurship schools, as seen in 47% of the 30 U.S.-based initiatives. However, other locations were identified, with 13% housed in the business school, 13% housed within all the schools of the institution, 10% housed in both the engineering and business schools, and 7% housed in the engineering school. Three exceptions were identified – one initiative was housed in the architecture school, another was housed in the Schools of Entrepreneurship and Business, and the third was housed in the Schools of Entrepreneurship and Engineering. In Australia, one initiative was housed in a freestanding entrepreneurship school while the other was housed in the business school. In contrast, all U.K. initiatives were housed in freestanding entrepreneurship schools or innovation centres.

Overall, the findings showed that *Institution* model initiatives were developed by the institution on a whole with all schools contributing to the creation and development process. Furthermore, the findings showed that although these initiatives were primarily housed in freestanding entrepreneurship schools, they could also be housed in other schools at the institution.

6.7.2: The curriculum used in *Institution* model entrepreneurship initiatives

The three broad curriculum types used in entrepreneurship initiatives for engineering undergraduates were business-focused (centred around the creation and running of new ventures), technologically-focused (centred on the creation and new technologies and products in response to the needs of society), and entrepreneurship-focused (designed to arm students with knowledge on entrepreneurship and its associated theories and concepts). To determine the curriculum used in *Institution* model initiatives, entrepreneurship initiative and course descriptions on institution webpages were reviewed and compared to the descriptions of three curriculum types.

The study found that the individual schools of the institution or the freestanding entrepreneurship school held the responsibility for curriculum development. U.S. initiatives predominantly used a curriculum that was both business- and technologically-focused, as seen in 43% of the 30 U.S. initiatives. Furthermore, 40% used a business-, technologically-, and entrepreneurship-focused curriculum, 10% used a business- and entrepreneurship-focused curriculum, and 7% used a technologically-focused curriculum. In the Australian initiatives, one used a business-, technologically-, and entrepreneurship-focused curriculum, while the other used a curriculum that was business- and entrepreneurship-focused. Of the three U.K. initiatives, one used a business- and entrepreneurship-focused curriculum, while the remaining two initiatives used a business- and technologically-focused curriculum.

Overall, the findings first revealed that *Institution* model entrepreneurship initiatives did not have a specific curriculum type. This followed the findings of the previous models discussed, where different curriculum types were identified in the review of the initiatives. Moreover, the findings showed that the initiatives mainly used a curriculum comprised of two or all three of the broad curriculum types. As seen in the previous models discussed, these findings suggest that entrepreneurship initiatives could follow the same model without having to use the same curriculum focus.

6.7.3: Target students of *Institution* model entrepreneurship initiatives

Determining the target students of *Institution* model initiatives required the review of descriptions of entrepreneurship initiatives on institution webpages in order to determine which students the initiatives were designed for. Taking the name of the model and the schools responsible for the creation and development into consideration, it was expected that the target students would be all undergraduates at the institution, regardless of major being pursued.

The findings confirmed that the target students of these initiatives in the institutions of all three countries were all undergraduates at the institution. This suggested that these initiatives were designed to construct a multi-disciplinary student cohort and working environment which facilitated the entrepreneurial learning experience. This is in line with the requirement for entrepreneurial engineers to have multi-disciplinary skills sets and work on teams with individuals from a variety of backgrounds and experiences, as discussed in section 2.2.

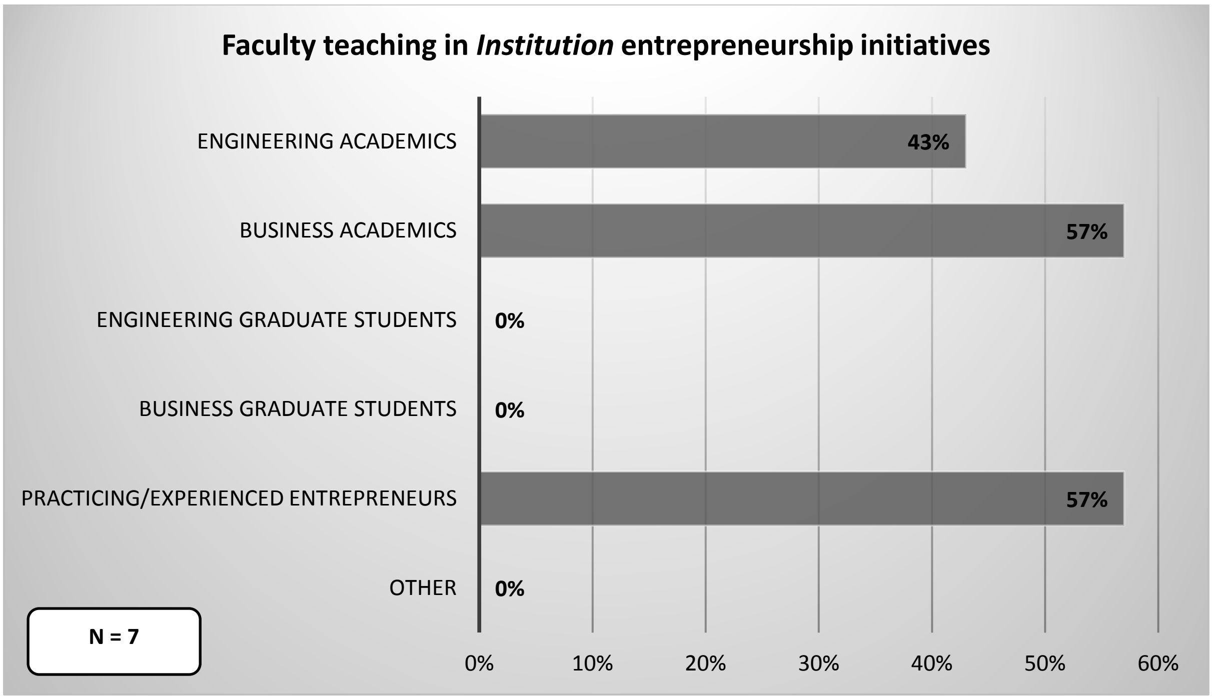
6.7.4: The location where the courses in *Institution* model entrepreneurship initiatives are taught and the faculty responsible for the teaching of entrepreneurship

To identify where courses were taught in *Institution* model initiatives, the course listings on institutions' webpages were reviewed to identify which schools held the responsibility for course delivery. To determine which faculty members taught these courses, the faculty pages on the webpages were reviewed. The online questionnaire sent to engineering school administrators was also used to acquire information regarding whether courses were taught by engineering academics, business academics, engineering graduate students, business graduate students, practicing or experienced entrepreneurs, or any additional groups.

First, the findings revealed that the courses for 33% of the 30 U.S-based initiatives were taught in freestanding entrepreneurship schools. In 23% of the initiatives, courses were taught in both the engineering and business schools. In a further 17% of the initiatives, courses were delivered in the various schools of the institution, while in 10%, courses were delivered in the business school. In two initiatives, the courses were delivered in some but not all of the schools at the institution. There were however three exceptions – in one initiative, the courses were taught in the architecture school, in another, the courses were taught in the engineering school, and in the third case, the courses were delivered in both the Schools of Entrepreneurship and Engineering. The findings further revealed that in Australian initiatives, the entrepreneurship courses of one initiative were delivered in a freestanding entrepreneurship school, while the courses of the other were taught in the business school. In the U.K. initiatives, 2 of 3 initiatives delivered its courses in a freestanding entrepreneurship school, while the final initiative delivered its courses in the engineering school.

With regards to the faculty responsible for teaching the entrepreneurship courses, the findings showed instances where the faculty members came from the schools within which the entrepreneurship courses were delivered. As a result, faculty members were not only from freestanding entrepreneurship schools, but also from the Schools of Engineering, Business, and Architecture. The questionnaire data collected from 7 of the 9 administrators whose initiatives followed the *Institution* model showed that courses were taught by the three faculty groups identified in the previous models. This is shown in Figure 37.

Figure 37: The types of faculty teaching entrepreneurship courses in *Institution* model entrepreneurship initiatives



As presented in Figure 37, entrepreneurship courses were taught by business academics, engineering academics, and practicing or experienced entrepreneurs. In contrast to the previous models, the data shows practising or experienced entrepreneurs played a greater role in teaching entrepreneurship. Moreover, based on the data presented in Figure 37, it can be suggested that the business and engineering schools play an important role in the teaching of entrepreneurship in *Institution* model initiatives.

Overall, the findings showed that entrepreneurship courses in *Institution* model initiatives were primarily taught in freestanding entrepreneurship schools. However, like the previous models, the findings also showed that courses can be taught in other locations. As a result, courses do not have to be delivered solely in freestanding entrepreneurship schools in order for initiatives to be classed as *Institution* model initiatives. Moreover, although courses were primarily taught in freestanding entrepreneurship schools, the findings showed that faculty members from the business and engineering schools played a significant role in the teaching of entrepreneurship. The findings also support those of the previous models where it was recognised that benefits could be gained in the entrepreneurial learning process by having both academics and practicing entrepreneurs use their knowledge and experiences to teach students about entrepreneurship.

6.7.5: The motivating factors behind the creation of *Institution* model entrepreneurship initiatives

To identify the motivating factors which resulted in *Institution* model initiatives, engineering school administrators were asked to select from a number of factors listed on the questionnaire. All 9 of the administrators whose initiatives followed the *Institution* model provided details about their motivating factors.

The study found that the single motivating factor in all cases was the desire to develop an institution-wide initiative that enabled all undergraduate students, regardless of their disciplines, to be educated about entrepreneurship. These findings could indicate an intention for students from a variety of educational backgrounds to collaborate on entrepreneurial activities, thereby enabling collaborative learning. Moreover, these findings suggested a drive towards the development of multi-disciplinary learning and teamwork.

6.7.6: The objectives of *Institution* model entrepreneurship initiatives

Entrepreneurship initiatives for engineering undergraduates have four objectives, which enable academic institutions to educate “about” and “for” entrepreneurship. As explained in section 5.6, the initiatives are designed in order for students to acquire a greater understanding of entrepreneurship, develop an entrepreneurial mindset, gain the knowledge and skills to be entrepreneurial and act entrepreneurially, and gain hands-on practical experiences in entrepreneurship. In order to determine the *Institution* model initiative objectives, the questionnaire sent to engineering school administrators asked respondents to state the objectives of their initiatives.

Like the findings of the previous models, the findings based on data collected from the 9 administrators whose initiatives use the *Institution* model have shown that together the initiatives offer the four objectives, but that each *Institution* model initiative had either one or two of these four objectives. For example, respondents R52 and R76 stated:

Respondent ID	Objective
R52	*"Understanding of innovation and product development process."*
R76	*"The program provides opportunities to students to learn about entrepreneurship – the process of creating value through recognizing and developing opportunities."*

Overall, the findings showed that initiatives following the *Institution* model did not necessarily have the same objectives, which supports the suggestion that initiatives that belong to a specific model could either have the same objectives or different objectives.

6.7.7: The types of educational programmes offered in *Institution* model entrepreneurship initiatives

As discussed in section 5.7, entrepreneurship initiatives for engineering undergraduates offer five educational programme options: entrepreneurship-based bachelor degree programmes, short entrepreneurship programmes, entrepreneurial experiential or practical learning programmes, individual entrepreneurship courses, and individual entrepreneurial engineering courses and projects. Entrepreneurship initiative descriptions available on the institutions' webpages were reviewed to determine which of these five options were offered in *Institution* model initiatives.

The findings revealed that U.S.-based initiatives offered four of the five programme types. The primary type offered was short entrepreneurship programmes in the form of academic minor and certificate programmes. This finding was similar to the U.S.-based initiatives of the previous models, where the findings had revealed that academic minor and certificate programmes were the primary type offered. The minor and certificate programmes offered in *Institution* model initiatives were in general entrepreneurship, innovation, innovation and entrepreneurship, innovation engineering, social innovation, and social entrepreneurship. *Institution* model initiatives in the U.S. also offered short entrepreneurship programmes focused on the development of ideas, business creation, and product development, individual entrepreneurship courses which were offered as electives to supplement undergraduate degrees, and entrepreneurial experiential programmes where students, for example, undertook business and design projects to design and develop new technologies to solve real-world problems, developed new product and business ideas, created new ventures, or developed solutions to real-world problems. In addition, the findings showed that U.K.-based initiatives offered entrepreneurship experiential programmes, with two of the initiatives including some coursework. With regards to the Australian initiatives, the initiative housed in the business school offered a short entrepreneurship programme in the form of a minor in general entrepreneurship, while the initiative housed in the freestanding entrepreneurship and innovation school was an entrepreneurship-based bachelor degree designed to be added as a second degree to all other bachelor degrees at the institution.

Overall, the findings showed that *Institution* model initiatives offered all of the types of educational programmes with the exception of individual entrepreneurial engineering courses and projects. This showed that like the initiatives of the previous models, there is no specific type of programme that can be classified as being offered by *Institution* model initiatives.

6.7.8: The practical experiences offered in *Institution* model entrepreneurship initiatives

In order to identify the types of practical experiences offered in *Institution* model entrepreneurship initiatives, the descriptions of co-curricular activities (for-credit practical entrepreneurship activities) and extra-curricular activities (not-for-credit practical entrepreneurship activities) available on institutions' webpages reviewed.

The findings revealed that *Institution* model initiatives across the three countries primarily offered "Business Creation" activities. The data showed that students gained experienced by generating and developing ideas for new business ventures, producing business plans for new ventures, pitching venture ideas in order to gain feedback and potential investment, and launching new ventures. In addition, the findings showed that several initiatives offered "New Technology Creation" or "New Product Creation" activities, where students derived new technologies or products based on societal needs, designed and developed prototypes for new technologies/products, wrote business plans, and pitched them to potential investors. Other practical experiences were also identified in each country, as shown in Table 41.

Table 41: *Institution* model entrepreneurship initiative co-curricular and extra-curricular activities offered to engineering undergraduates in Australia, the United Kingdom, and the United States

Examples of *Institution* model entrepreneurship initiative co-curricular and extra-curricular activities	
Country	**Co-curricular/Extra-curricular activity**
Australia	Business creation activities
	New technology/new product creation activities
	Participation in interdisciplinary team projects for real-world clients
	Preparation of innovation reports
	Generation of solutions to business problems
	Undertaking of industry projects for real-world clients
	Undertaking of innovation projects
	Work experience either from internships at existing companies or simulated workplace contexts
The United Kingdom	Business creation activities
	New technology/new product creation activities
	Work experience in established companies through internships and job placements
	Participation in entrepreneurship competitions and challenges, boot-camps, conferences, lectures, workshops, and seminars
	Participation in entrepreneurship clubs, societies, and organisations
	Networking opportunities with other individuals who have entrepreneurial interests
	Opportunities to be mentored by individuals with entrepreneurial experience
The United States	Business creation activities
	New technology/new product creation activities
	Identification, evaluation, assessment, and development of potential opportunities (and proposal of the launch of a company)
	Work experience in established companies through internships and job placements
	Participation in interdisciplinary team projects for real-world clients
	Participation in real-world design projects
	Evaluation of the suitability of a technology as a product or service
	Acting in consultant roles for small businesses or start-ups
	Design, development and testing of solutions to real-world problems
	Participation in entrepreneurship clubs, societies, and organisations
	Participation in entrepreneurship competitions and challenges, boot-camps, conferences, lectures, workshops, and seminars
	Networking opportunities with other individuals who have entrepreneurial interests
	Opportunities to be mentored by individuals with entrepreneurial experience

Overall, as shown in Table 41, experiences in business creation were the primary types of experiences students gain when they participate in *Institution* model initiatives. The findings also revealed the similarities in the types of practical experiences offered in *Institution* model initiatives to the initiatives of the previous models discovered. Furthermore, these findings suggested that there were similarities among the *Institution* model initiatives across Australia, the United Kingdom, and the United States.

6.7.9: The entrepreneurial competencies emphasised in *Institution* model entrepreneurship initiatives

The engineering school administrators who responded to the online questionnaire were asked whether or not they emphasised any of the 13 Morris et al. (2013b) competencies by identifying the level of emphasis placed on each competency. On a five-point Likert scale, administrators had to indicate the level of emphasis by choosing one of the following five options: '*No emphasis*', '*Some emphasis*', '*Moderate emphasis*', '*Major emphasis*', or '*Significant emphasis*'. The findings from the data collected from the 9 engineering school administrators whose initiatives used the *Institution* model is presented in Table 42.

Table 42: The entrepreneurial competencies significantly or majorly emphasised in *Institution* model entrepreneurship initiatives

The entrepreneurial competencies significantly and majorly emphasised in *Institution* model entrepreneurship initiatives [N = 9]	
Entrepreneurial competency	**% of respondents**
Creative Problem Solving	56
Resource Leveraging	44
Opportunity Recognition	33
Opportunity Assessment	33
Tenacity or Perseverance	33
Value Creation	33
Self-Efficacy	33
Building and using networks	33
Risk Management	22
Conveying a compelling vision	22
Guerrilla Skills	22
Maintain Focus yet adapt	22
Resilience	11

*competencies are listed from the competency that has been significantly/majorly emphasised by the greatest number of respondents to the competency that has been significantly/majorly emphasised by the least number of respondents

As shown in Table 42, the 13 of the entrepreneurship competencies were either majorly or significantly emphasised in *Institution* model initiatives. Furthermore, the findings showed that *Creative Problem Solving* was the competency that was majorly or significantly emphasised in the majority of the 9 initiatives, and was the only competency to be majorly or significantly emphasised by more than 50% of the administrators. The fact that this competency was majorly or significantly emphasised by the majority of the administrators was an interesting finding because it was the competency that was majorly or significantly emphasised within the majority of the initiatives following the *Business School*, *Multi-School*, and *External Partnership* models. Furthermore, *Resilience* was majorly or significantly emphasised in the small percentage of *Institution* model initiatives, a fact that was seen for the *Business School* and *Multi-School* model initiatives.

Overall, the data provided by the 9 administrators seen in Table 42 suggests that in *Institution* model initiatives, more emphasis is placed on teaching students how to produce new, useful outputs given available resources as opposed to students learning how to handle the potential stressful situations that could arise from setbacks. As recognised in the initiatives of the previous models, all 13 of the competencies are emphasised. However, the findings suggest that some competencies are considered more valuable to becoming entrepreneurial as opposed to others.

6.7.10: The opportunities experienced in *Institution* model entrepreneurship initiatives

Entrepreneurship initiatives for engineering undergraduates generally offer 10 opportunities for students to gain experience in entrepreneurship, as discussed in section 5.9. To identify if these 10 opportunities and any other opportunities were offered in *Institution* model initiatives, engineering school administrators were asked on the questionnaire to identify the opportunities their initiatives offered.

The analysis of the data collected from the nine administrators whose initiatives used the *Institution* model showed that the 10 opportunities were offered in their initiatives, as shown in Table 43.

Table 43: The opportunities engineering undergraduates experience in *Institution* model entrepreneurship initiatives

The opportunities engineering undergraduates experience in *Institution* model entrepreneurship initiatives [N = 9]	
What engineering undergraduates experience	**% of respondents**
Intern or work for an entrepreneurial or start-up company	67
Give an “elevator pitch” or presentation to a panel of judges about a product or business idea	67
Be involved in patenting a technology or protecting intellectual property	67
Be involved in entrepreneurship- or business-related student organisations	67
Participate in an entrepreneurship-related competition	67
Participate in entrepreneurship-related workshops	67
Conduct market research and analysis for a new product or technology	56
Develop a product or technology for a real client/customer	56
Write a business plan	56
Take an entrepreneurship course within the Faculty/School of Engineering	44

Based on the data presented in Table 43, the opportunities offered in the majority of initiatives were more varied in comparison to the opportunities offered in the majority of the initiatives following the four previous models. The majority of the 9 administrators stated that their initiatives offered various activities for students to experience entrepreneurship ranging from work experience to elevator pitches to the patenting of new technologies. This suggests a desire for students in these initiatives to gain a more rounded approach when it came to experiencing entrepreneurship.

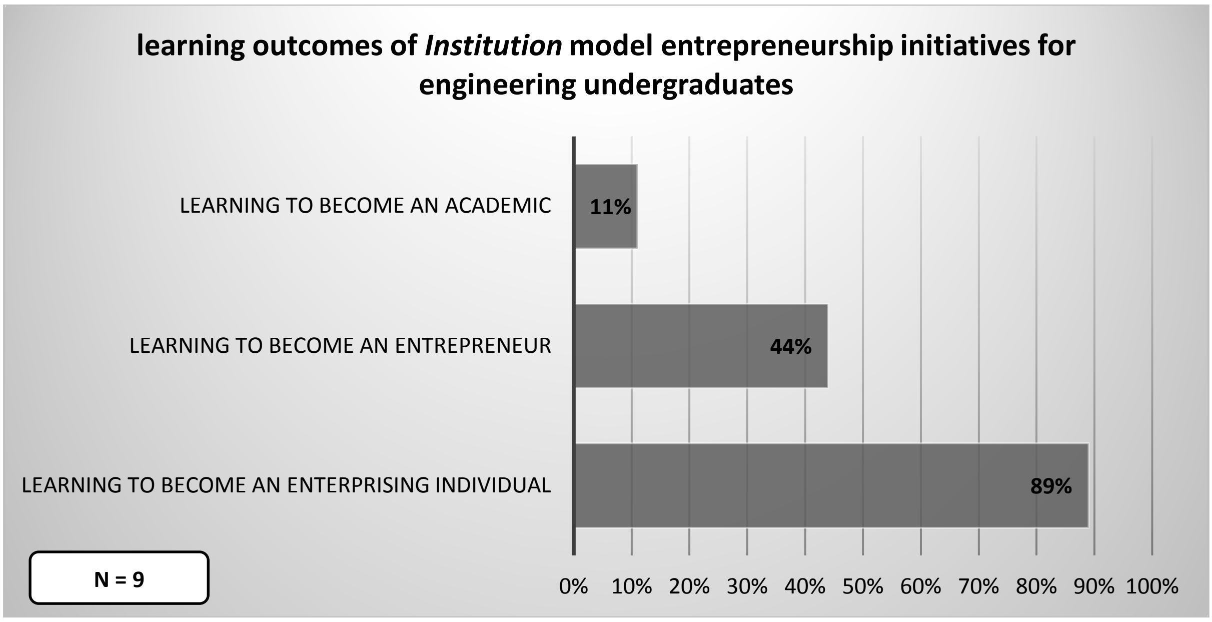
Overall, the findings show that the initiatives of the 5 models offer the same opportunities for experience in entrepreneurship to be gained. However, with regards to the *Institution* model initiatives, the findings show that initiatives differ in terms of what opportunities are offered. Furthermore, as revealed in the findings, some activities are considered more important for the entrepreneurial experience when compared to others.

6.7.11: The outcomes of *Institution* model entrepreneurship initiatives

To identify the outcomes of the initiatives that follow the *Institution* model, the questionnaire sent to engineering school administrators first asked respondents to state whether their initiatives educated their students to become enterprising individuals, entrepreneurs, and/or entrepreneurship academics, and then asked respondents to identify which careers their students could pursue after participation in their initiatives.

Based on the data collected from 9 administrators, the findings revealed that *Institution* model initiatives educated their students to become enterprising individuals, entrepreneurs, and academics. This is presented in Figure 38.

Figure 38: The outcomes of Institution model undergraduate entrepreneurship initiatives



As shown in Figure 38, the initiatives primarily educated students to become enterprising individuals, with the focus being on the development of an entrepreneurial mindset. The findings revealed a similarity to the outcomes of the *External Partnership* model, regarding the significant gap between the percentage of respondents who stated that the goal was for students to become enterprising individuals and those who stated that becoming an entrepreneur was a goal. A link could also be drawn between the outcome of becoming an enterprising individual and the range of opportunities offered in these initiatives, shown in section 6.7.10, with students undertaking a variety of activities that enable them to act in entrepreneurial ways.

The findings also revealed that the initiatives prepared students to pursue the same careers that initiatives of the previous models prepared their students for. This is shown in Table 44.

Table 44: What engineering undergraduates are prepared to do after participation in *Institution* model entrepreneurship initiatives

What engineering undergraduates are prepared to do after participation in *Institution* model entrepreneurship initiatives [N = 9]	
What engineering undergraduates are prepared to do	**% of respondents**
Start their own business or be self-employed	56
Work for a small business or start-up company	56
Work for a medium- or large-size business	56
Attend graduate/professional school	56
Work for a social enterprise	33
Work for a non-profit organisation	33

As seen in Table 44, *Institution* model initiatives mainly prepare students to further their education in graduate and professional school, start their own ventures, or gain work experience by working in small, medium, or large companies. The findings also show that there was less of a focus on the preparation of students to undertake careers in the social sector, which could be due to the fact that Entrepreneurial Engineers are primarily required to contribute to the performance of an economy through the creation of jobs and the generation of profit.

Overall, the findings showed that despite the presence of other outcomes, the main outcome of *Institution* model initiatives was the education of students to become enterprising individuals. Moreover, *Institution* model initiatives prepared students to either pursue postgraduate degrees or pursue careers in companies where the generation of profit was the main goal, and not necessarily careers in companies aimed at addressing the needs of society.

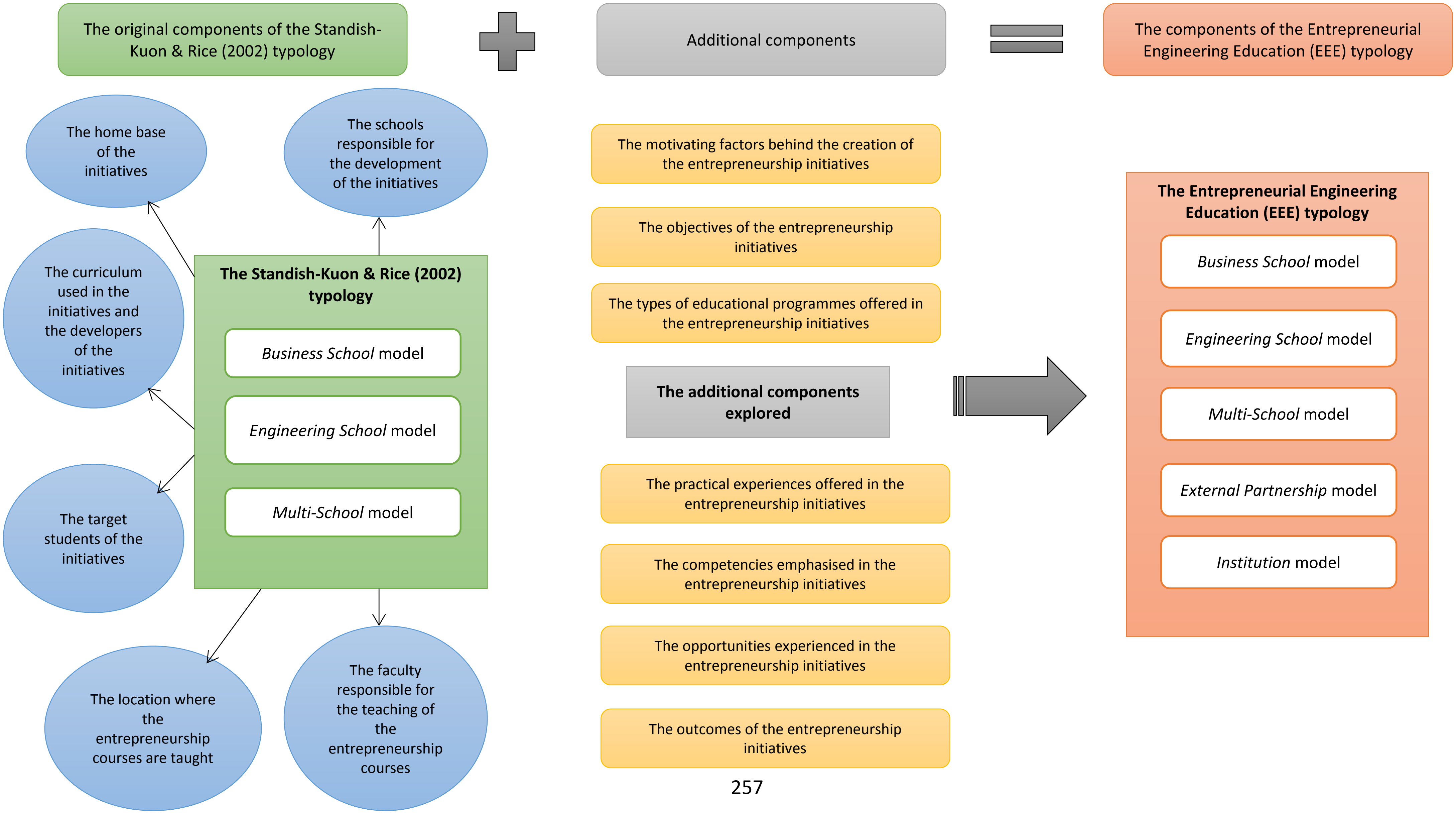
6.8: Chapter Summary

This chapter presented the Entrepreneurial Engineering Education (EEE) Typology, a new typology which contains the models used by institutions to educate engineering undergraduates about entrepreneurship. This typology consist of five models: the *Business School* model (used to describe initiatives developed either solely by the business school or the business and another school and housed in the business school), the *Engineering School* model (used to describe initiatives developed either solely by the engineering school or by the engineering and business schools and housed in the engineering school), the *Multi-*

School model (used to describe initiatives developed from a partnership involving the engineering school, the business school, and one or more of the other schools), the *External Partnership* model (used to describe initiatives developed from a partnership primarily involving the engineering school and an external organisation or institution), and the *Institution* model (used to describe initiatives resulting from an academic institution's desire to educate all students, regardless of major, about entrepreneurship). A summary of the EEE typology and its associated components, which ultimately presents the overall outcome of this PhD study, is presented in Figure 39.

The following chapter, Chapter 7, presents a discussion of the research findings through an assessment of the Entrepreneurial Engineering Education (EEE) typology.

Figure 39: The Entrepreneurial Engineering Education (EEE) Typology and the associated components (Outcome of the PhD study)



Chapter 7: Discussion

7.1: Introduction

Chapter 7 contains a discussion of the research findings, presenting an assessment of the Entrepreneurial Engineering Education (EEE) typology using Hunt's (1976, 2010) criteria for acceptable classification schemata.

7.2: The assessment of the Entrepreneurial Engineering Education (EEE) Typology

The findings of the research, as presented in Chapter 6 were used to develop the emergence of the Entrepreneurial Engineering Education (EEE) typology. This typology is an extension of the Standish-Kuon and Rice (2002) typology and shows how tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States educate engineering undergraduates about entrepreneurship. The typology also provides a way of categorising entrepreneurship initiatives developed for engineering undergraduates.

To demonstrate the value and utility of the EEE typology, it was necessary to assess the typology's strength for categorising entrepreneurship initiatives for engineering undergraduates. The assessment of the typology was conducted using Hunt's (1976, 2010) criteria for acceptable classification schemata. The Hunt criteria is one of the most widely used for the classification of different phenomenon and has been cited in numerous examples, including *Avlonitis et al. (1999); Avlonitis et al. (2001); Brandtzæg (2010); Bunn (1993); Cunningham et al. (2009); Cunningham et al. (2008); Cunningham et al. (2006); Cunningham et al. (2004); Forbes et al. (2005); Greig (2003); Hassanien and Dale (2011); Leong (1985); McCorkle (1990); Moe (2003); Moncrief et al. (1989); Morris and Pitt (1993); Papastathopoulou and Avlonitis (2009); Tellis (1986); Varadarajan (1986)*. Furthermore, it has been proven valuable for assessing the strength of, and evaluating, a range of different typologies, as shown in Table 45.

Table 45: Examples of research studies that used the Hunt (1976, 2010) criteria

Researchers	Use of the Hunt (1976, 2010) criteria
Fern and Brown (1984)	Evaluation of the industrial/consumer dichotomy
Samli and Bahn (1992)	Evaluation of a classification scheme for definitions of market and key proponents
Kelley et al. (1993)	Evaluation of a typology of retail failures and recovery strategies
Darmon (1998)	Assessment of a typology for classifying sales positions
Covin and Miles (1999)	Evaluation of a typology of corporate entrepreneurship
Halstead (1999)	Evaluation of a typology of comparison standards in customer satisfaction research
Acar et al. (2001)	Validation of a typology describing the organisational spectrum from the fully for-profit to the fully non-profit organisations
Harrison-Walker and Neeley (2004)	Evaluation of a typology for B2B Customer Relationship Building
Wales et al. (2011)	Comparison of three models of how Entrepreneurial Orientation may pervade organisations

The recognition and use of Hunt's work across the last four decades demonstrates its acceptance. As a result, the decision was made to use the Hunt (1976, 2010) criteria to assess the strength of the EEE typology.

Classification Schemata is a way of organising phenomena into classes or groups that open the possibilities for investigation and theory development to occur (Hunt 1976, 2010). Using this classification schemata, Hunt (1976, 2010) stated that an accepted typology is one that will:

1. adequately specify the phenomenon to be classified;
2. adequately specify the properties or characteristics that will be doing the classifying;
3. have mutually exclusive categories;
4. have collectively exhaustive categories; and
5. be useful.

The strength of the EEE typology is discussed in the following sub-sections by presenting an assessment of the typology against the five Hunt (1976, 2010) criteria.

7.2.1: Does the EEE typology adequately specify the phenomenon to be classified?

As explained in Chapter 6, the EEE typology of models is a representation of how tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States are educating their engineering undergraduates about entrepreneurship. The first of Hunt's (1976, 2010) criteria for classification schemata asks whether or not the 'what' which is being categorised has been identified. Here, the 'what' referred to the unit of analysis used in this research. The unit of analysis was the individual entrepreneurship initiative for engineering undergraduates, and not the institution; as evidenced by cases where institutions offered multiple initiatives, with each following a different model.

In the original study conducted by Standish-Kuon and Rice (2002), the researchers sought to examine how engineering and science students were being introduced to entrepreneurship by exploring the technologically-oriented entrepreneurship initiatives offered at six U.S. universities. These initiatives, offered by the first institutions to design entrepreneurship initiatives for engineering and science students, were selected via convenience sampling based on the geographical diversity of the institutions, the institutions' reputation for engineering and the sciences, and the presence of entrepreneurship centres or programmes at the institution. The initiatives the researchers explored were either at the undergraduate or postgraduate level, and using similarities identified amongst the initiatives, they were able to categorise them into three distinct models.

In comparison, this research also involved the categorisation of entrepreneurship initiatives. However, the initiatives reviewed were specifically at the undergraduate level. Whereas convenience sampling was used in the Standish-Kuon and Rice (2002) to select the entrepreneurship initiatives to be reviewed, this research used purposive sampling, with initiatives that directly fit the purpose of this research being included. This involved determining of the population of institutions from Australia, Canada, New Zealand, the United Kingdom, and the United States that offered undergraduate engineering programmes accredited by the main engineering education accreditation boards in each country. The main criteria used to determine the initiatives to be included in this research was first, that the institution offered an undergraduate engineering programme accredited by the main accreditation board in each of the five countries, and second, that the institution offered opportunities for engineering undergraduates to learn about entrepreneurship.

To acquire information regarding entrepreneurship initiatives in the Standish-Kuon and Rice (2002), the researchers employed a year-long longitudinal study where they did site visits to the institutions, conducted in-person and telephone interviews, analysed internal documents, and ended with follow-up surveys. In contrast, to acquire information about the entrepreneurship initiatives reviewed in this research, the engineering programme descriptions were reviewed to determine whether or not initiatives in entrepreneurship, in any form, were additionally offered to the engineering students. In reviewing the programme descriptions, evidence of entrepreneurship was sought in the engineering descriptions – this included different programmes, courses, and any similar offerings that allowed students to gain knowledge and experience in entrepreneurship. This approach was taken in order to allow a census to be performed of all available entrepreneurship initiatives for engineering undergraduates in the five countries.

Despite the difference in the approach taken in this research study when compared to the approach taken in the Standish-Kuon and Rice (2002) study, the development of the typology in both research studies resulted from information acquired from the entrepreneurship initiatives. The typology was developed based on the categorisation of the different entrepreneurship initiatives that were offered to engineering undergraduates. As a result, criterion one has been addressed.

7.2.2: Does the EEE typology adequately specify the properties or characteristics that will be doing the classifying?

Criterion two of the Hunt (1976, 2010) criteria for classification schemata focuses on whether or not the properties or characteristics used in the classification are appropriate and used consistently throughout the classification process. In this research study, the characteristics used included the six characteristics used by Standish-Kuon and Rice (2002) in the description of each of their models, and seven additional characteristics acquired from entrepreneurship education literature (see Table 46). Each of the 13 characteristics used in this research provided valuable insight into the models of the EEE typology.

Table 46: The characteristics used to describe the models of the Entrepreneurial Engineering Education (EEE) Typology

The characteristics used to describe the models of the EEE typology				
Characteristics	**Rationale for the use of the characteristic**	**The Source for the rationale for the use of the characteristic**	**Usefulness of the characteristic**	**The use of the data for future research**
The schools responsible for the development of the entrepreneurship initiatives	initial identification of the model that each initiative followed	Standish-Kuon and Rice (2002)	Categorisation of initiatives	Yes
The home base of the entrepreneurship initiatives	Identification of the initiatives that belonged to a particular model	Standish-Kuon and Rice (2002)	Categorisation of initiatives and Description of models	Yes
The curriculum used in the entrepreneurship initiatives and the developers of the curriculum	Insight into the direction of the entrepreneurship initiatives within each of the models, as well as the focus of the initiatives	Standish-Kuon and Rice (2002)	Description of models	Yes
The target students of the entrepreneurship initiatives	Identification of the audiences that entrepreneurship initiatives were designed for	Standish-Kuon and Rice (2002)	Description of models	Yes
The location where the courses of the entrepreneurship initiatives are taught	Insight into the teaching of entrepreneurship within each of the models	Standish-Kuon and Rice (2002)	Description of models	Yes
The faculty responsible for teaching the courses of the entrepreneurship initiatives	Insight into the teaching of entrepreneurship within each of the models	Standish-Kuon and Rice (2002)	Description of models	Yes
The motivating factors behind the creation of the entrepreneurship initiatives	Identification of factors which led to the presence of initiatives of specific models	Standish-Kuon and Rice (2002)	Description of models	Yes

The objectives of the entrepreneurship initiatives	Determination of whether initiatives that followed different models had different objectives	Fayolle and Gailly (2008)	Description of models	Yes
The types of educational programmes offered in the entrepreneurship initiatives	Determination of the programmes that initiatives in each model offered for students to learn about entrepreneurship	Fayolle and Gailly (2008)	Description of models	Yes
The practical experiences offered in the entrepreneurship initiatives	Determination of the experiences that initiatives in each model offered for students to learn about entrepreneurship	Fayolle and Gailly (2008)	Description of models	Yes
The competencies emphasised in the entrepreneurship initiatives	Identification of whether or not certain competencies were emphasised in initiatives following a particular model	Fayolle and Gailly (2008) Morris et al. (2013b)	Description of models	Yes
The opportunities experienced in the entrepreneurship initiatives	Determination of whether there were differences in the opportunities that initiatives following each model offered	Fayolle and Gailly (2008)	Description of models	Yes
The outcomes of the entrepreneurship initiatives	Determination of whether or not initiatives that followed a specific model had different outcomes	Fayolle and Gailly (2008)	Description of models	Yes

The first characteristic, *the schools responsible for the development of the entrepreneurship initiatives*, was an important characteristic for this research as it assisted with both the categorisation and description of the entrepreneurship initiatives. This characteristic was used to initially identify the model that each initiative followed, which meant that this particular characteristic was critical to the execution of the research. To describe each model, it was first necessary to categorise the initiatives, and, as a result, this characteristic was essential for the purpose of categorisation.

The home base of the entrepreneurship initiatives was also an important characteristic, although not as important as the first characteristic for some of the models. The home base of the initiatives referred to the location where the initiatives were housed or situated. In the Standish-Kuon and Rice (2002) study, the findings showed that the initiatives following each of the three models were housed in specific schools, which made this characteristic useful in the identification of the model that a particular initiative followed. For this research study, this characteristic, although important, played different roles depending on the model. In this research study, the initiative descriptions on the institutions' webpages were reviewed to identify the schools within which the initiatives were housed. In comparison to the importance of the home base of the initiative shown in the findings from the Standish-Kuon and Rice (2002) study, the role of this characteristic in this research was diminished. For the *Multi-School*, *External Partnership*, and *Institution* models, the home base of the initiatives was not a characteristic that was essential to consider when categorising the initiatives. This was because the schools responsible for the creation and development of the initiative were sufficient for the categorisation of initiatives that followed these models. Furthermore, the findings showed a number of different home bases for initiatives following each of these three models. This meant that this characteristic was not ideal for categorising initiatives that followed these three models. Like the *Multi-School*, *External Partnership*, and *Institution* models, the home base of some of the initiatives following the *Business School* and *Engineering School* models did not play a significant role. However, this characteristic was particularly important for initiatives that were created by both the engineering and business schools. The home base was necessary to identify the initiatives which followed the *Business School* model and the *Engineering School* model. To determine which of the initiatives created by both the business and engineering schools followed either the *Business School* or *Engineering School* models, it was necessary to look at the home base of the initiative. For the initiatives created by the two schools, a *Business School* model initiative was one housed in the business school, while an *Engineering School* model initiative was one housed in the engineering school. As a result, the home base of the initiative was critical for categorisation purposes in this case.

The *curriculum used in the entrepreneurship initiatives* describes, for example, the resources, materials, course content, and educational processes that are involved in the initiatives. These, therefore, determine the focus, structure, and direction of the entrepreneurship initiatives. In the Standish-Kuon and Rice (2002) study, the researchers' investigation of technically-based entrepreneurship initiatives showed that a technological entrepreneurship curriculum was used. In contrast, this research study reviewed all types of entrepreneurship initiatives that were offered to engineering undergraduates, as opposed to limiting the review to technologically-oriented entrepreneurship initiatives. The purpose of reviewing the types of curriculum used in entrepreneurship initiatives for engineering undergraduates was to gain insight into the direction of the entrepreneurship initiatives within each of the models, as well as the focus of the initiatives. In the research, the value of this characteristic was for descriptive purposes as opposed to categorisation. This was because the initiatives of each model had numerous curriculum types. In addition, the findings showed that initiatives that have the same curriculum types could ultimately follow different models. Therefore, although the curriculum identification was important for describing the structure of a model, it was not useful for the categorisation of initiatives into their respective models.

The target students of the entrepreneurship initiatives referred to the audiences or types of students for whom the entrepreneurship initiatives were designed. The main purpose of this characteristic was used to determine whether the initiatives were designed solely for engineering undergraduates, or if engineering undergraduates were joined by undergraduates from other disciplines. As a result, the intention was to determine if certain models were used to target or educate particular types of students. In the Standish-Kuon and Rice (2002) study, the research investigations determined the target groups of students. A similar approach was used in this research project, where the descriptions of the entrepreneurship initiatives were reviewed for information regarding the types of students that were targeted. These were then compared to information regarding target students from the description of the Standish-Kuon and Rice (2002) typology. This characteristic provided valuable insight in some instances. For example, the findings showed that initiatives designed specifically for engineering students generally followed either the *Engineering School* or *External Partnership* models. In addition, the findings showed that initiatives designed for all undergraduates could follow not only the *Institution* model, but also the *Business School* and *Multi-School* models. Despite these insights, the findings showed that initiatives from each model, with the exception of the Institution model, had a number of different target audiences. As a result, this characteristic was useful for model description, but not model categorisation.

The location where the courses of the entrepreneurship initiatives are taught and t*he faculty responsible for teaching the entrepreneurship courses* were two characteristics also identified in the Standish-Kuon and Rice (2002) study. The former of the two characteristics referred to the school or location within which the entrepreneurship courses of the initiatives were taught. As shown in the descriptions of the Standish-Kuon and Rice (2002) typology, despite an initiative being housed in a particular location, the courses could also be taught in other locations. These two characteristics were included in this research study in order to gain insight into the teaching of entrepreneurship within each of the models. The Standish-Kuon and Rice (2002) typology showed that courses in the initiatives following each of their three models were taught either in the business or engineering schools by faculty members from either of the two schools. In this research project, the entrepreneurship initiative descriptions were reviewed to see which courses were included in the programmes offered, the schools within which they were offered, and the faculty involved in teaching. Additional information about the faculty was also acquired from the online questionnaire sent to engineering school administrators. As identified in the research findings, the courses of entrepreneurship initiatives for each model were taught in different locations. The findings also showed that for each model, courses in initiatives were primarily taught by engineering academics, business academics, and practicing or experienced entrepreneurs. As a result, the findings showed that these two characteristics were useful for describing the teaching of entrepreneurship courses, but not for the categorisation of initiatives into their respective models.

In this study, seven additional characteristics were investigated to gain additional insight into initiatives in an attempt to further distinguish among the models. The purpose of including these characteristics was to provide more detailed descriptions and more accurate categorisation of the entrepreneurship initiatives. The first of these characteristics, *the motivating factors behind the development of entrepreneurship initiatives*, was investigated in the Standish-Kuon and Rice (2002) study. However, these were more broadly explored in this study. Given the importance of determining these factors in the Standish-Kuon and Rice (2002) study, the decision was made to see whether there were different factors at play which helped to distinguish among the models.

The remaining characteristics were included in this study because the design and structure of entrepreneurship education programmes are based around the responses to five questions (Fayolle & Gailly 2008). These questions included:

- ***Why?*** – the objectives and goals of entrepreneurship education programmes;
- ***For Whom?*** – the target groups or audiences of entrepreneurship education programmes;
- ***For Which Results?*** – the knowledge, skills and tools that are desired for students to possess and the effectiveness of the entrepreneurship education programmes;
- ***What?*** – the content and relevant theories taught in entrepreneurship education programmes which essentially allow students to have the knowledge, skills, and capabilities to operate in an entrepreneurial capacity; and
- ***How?*** – the methods and pedagogies which are used to achieve the objectives and goals of the entrepreneurship education programmes.

The goal of this research study was to learn about how tertiary-level academic institutions were educating their engineering undergraduates about entrepreneurship. As a result, the decision was made to identify the responses to these questions and use them to develop and describe the typology. However, the decision was made to not explore information about the effectiveness of programmes since it was beyond the scope of the study. The issue of effectiveness will be addressed in future research.

The six remaining characteristics provided information about four of the five questions; given that the target students of entrepreneurship initiatives was one of the initial characteristics identified in the original Standish-Kuon and Rice (2002) study. The *motivating factors behind the development of entrepreneurship initiatives*, referred to whether there were any significant factors in play that led to the emergence of particular initiatives. The purpose of including these characteristics in this research study was therefore to identify whether or not certain factors existed which led to the presence of initiatives of specific models. This characteristic proved useful in that the findings showed that for four of the five models there were common factors which led to the creation of the initiatives. However, for the *Engineering School* model, despite the presence of a primary factor, additional factors were identified, some of which were similar to those of the *Business School* and *Multi-School* models. As a result, this characteristic was useful for the categorisation of some initiatives. Despite this, this characteristic alone was insufficient for categorisation purposes.

The objectives of the entrepreneurship initiatives referred to the goal or purpose of the initiatives. In other words, it referred to what the institutions intended to achieve as a result of developing the initiative. Identification of the objectives was important in determining whether initiatives following different models had different objectives. Had the study found that there were distinct objectives for initiatives in each model, it would have assisted in the categorisation of the initiatives. However, as shown in Chapter Five, initiatives had one or two of four objectives. This meant that the initiatives following each model had different objectives, and, for example, two initiatives could possess the same objectives but follow different models. As a result, information pertaining to the objectives was useful in describing the initiatives of each model, but was found to be inadequate for categorisation purposes.

The types of educational programmes offered in the entrepreneurship initiatives and *the practical experiences offered in the entrepreneurship initiatives* were used to determine the programmes as well as experiences that initiatives in each model offered for students to learn about entrepreneurship. The goal was to determine if there were certain types of programmes associated with each of the five models. As discussed in section 5.7, there were five types of programmes used. The findings showed that each of the five types was present in initiatives following each model and no type could be classified as being offered by a particular model's initiatives. Furthermore, the findings showed that generally, initiatives offer the same practical experiences, regardless of the model that the initiative followed. As a result, the purposes of these particular characteristics were descriptive in lieu of categorisation.

The competencies emphasised in the entrepreneurship initiatives was examined to determine whether certain competencies were emphasised in initiatives following a particular model. For the purposes of this research, the 13 entrepreneurial competencies proposed by Morris et al. (2013b) were used. With regards to entrepreneurship education for engineering undergraduates, as explained in section 5.5, there were two factors identified that showed which of the 13 competencies the engineering school administrators who responded to the online questionnaire perceived as being essential for engineers to possess. The interpretation of these two factors was consistent with previous research on the competencies and characteristics that entrepreneurial individuals need to possess. There was a strong positive correlation between the factors ($r = 0.71$), and as a result, the results of the analysis support the use of Morris et al.'s (2013b) entrepreneurship competencies in research on entrepreneurial engineers.

With regards to the initiatives and the entrepreneurship competencies emphasised within each model, the findings showed that all 13 were emphasised in the initiatives for which data was available and demonstrated that the emphasis of each competency was not limited to initiatives following specific models. Therefore, the use of this characteristic was for descriptive, as opposed to categorisation, purposes.

Reviewing the entrepreneurship competencies also provided insight into the emphasis given in educational initiatives to developing student competencies related to opportunity recognition and opportunity assessment. Given that opportunity is the cornerstone or foundation of entrepreneurship (Shane & Venkataraman 2000), it was interesting to see that the findings showed that *Opportunity Recognition* and *Opportunity Assessment* were not as highly valued in the responses collected from the online questionnaire, in comparison to other competencies such as *Creative Problem Solving* and *Tenacity*. These results ultimately indicated that within engineering, learning about opportunity was perceived as less important by the tertiary-level academic institutions examined in this study. However, the investigation of the value placed on opportunity was not one of the objectives of this doctoral research and will be investigated in future studies.

The opportunities experienced in the initiatives was used to determine whether there were differences in the opportunities that initiatives following each model offered. Given that students must graduate with a variety of knowledge and skills, the review of this characteristic in this research provided insight into whether there were differences amongst the opportunities provided in the initiatives of each model. The findings showed that initiatives surveyed generally offered the same opportunities regardless of the models followed. As a result, this particular characteristic could not be used for the purposes of initiative categorisation.

The final characteristic, *the outcomes of the initiatives*, was used to determine whether initiatives that followed a specific model targeted different outcomes. By reviewing the outcomes of the initiatives in this study, insight into whether different models have different outcomes was acquired. However, as revealed in the findings shown in Chapter Six, the initiatives surveyed offered the same outcomes. This meant that *the outcomes of the initiatives* could not be used to identify the model that a particular initiative followed. As a result, this characteristic was used to describe a model as opposed to the identification of the model that an initiative followed.

Due to the variation among the characteristics of the initiatives, only one main characteristic could be used to identify the model that an initiative followed: *the schools responsible for the development of the* initiatives. This characteristic was useful in determining the model which is followed by each initiative. In addition, it eliminates the similarities seen in other characteristics. To illustrate this, for example, the business and engineering school were involved in the development of the *Business School*, *Engineering School*, *Multi-School*, and *External Partnership* models. In order to determine which model an initiative followed, the schools involved had to be identified. If the initiative included both the business and engineering schools as well as additional school at the institution, the initiative was identified as a *Multi-School* model initiative. If the initiative included the business and engineering schools and external organisations, it was classed as being an *External Partnership* model.

However, despite the use of the schools involved helping to identify the model an initiative followed, the findings showed that this characteristic was insufficient for distinguishing initiatives following the *Business School* and *Engineering School* models. Some initiatives following either the *Business School* or *Engineering School* model were created and developed by both the business and engineering schools. In order to distinguish between which followed the *Business School* model and the *Engineering School* model, the home base of the initiative had to be taken into consideration. The initiatives created and developed by both the engineering and business schools and housed in the business school was categorised as *Business School* model initiatives. In contrast, those created and developed by the two schools and housed in the engineering school were categorised as following the *Engineering School* model.

Overall, as presented in Table 46, *the schools responsible for the development of the entrepreneurship initiatives* was the characteristic that was essential for the categorisation of the initiatives into their respective models. Furthermore, to determine whether initiatives created and developed by both the business and engineering schools followed either the *Business School* or *Engineering School* models, it was necessary to use *the home base of the entrepreneurship initiatives* in order to facilitate the categorisation purpose. Although the remaining characteristics could not be used for classification purposes, they were still important in the description of each of the five models in the Entrepreneurial Engineering Education (EEE) typology. Using the description of the models of the EEE typology, the characteristics necessary for classification purposes were clearly identified and stated. This therefore showed that the second criterion was addressed.

7.2.3: Does the EEE typology have categories that are mutually exclusive?

Hunt (1976, 2010) defined the third criterion of mutual exclusivity as determining whether an item can fit into one class or category, and no other. In this research context, mutual exclusivity referred to whether each entrepreneurship initiative was able to be categorised into only one of the models of the EEE typology. In reviewing the findings from the Standish-

Kuon and Rice (2002), the schools that were responsible for the development of the entrepreneurship initiatives and the home base of the entrepreneurship initiatives were the characteristics that helped to identify which model a particular initiative followed. These were identified as the initial characteristics that helped to categorise the initiatives. For example, Standish-Kuon and Rice (2002) identified initiatives that were developed by and housed within the business school as following the *Business School* model. The researchers defined *Engineering School* model initiatives as those developed by and housed within the engineering school. *Multi-School* model initiatives were defined as initiatives that were developed by the business school, engineering school, and one or more technical schools, and housed within either the engineering or business schools. As a result, these characteristics helped to categorise initiatives, and aided in the mutual exclusivity of these categories or models.

In this research study, a similar approach was taken. Using the identifying characteristics from the Standish-Kuon and Rice (2002) study, the initiatives were initially categorised according to the *Business School*, *Engineering School*, and *Multi-School* models. The criteria used to categorise initiatives according to models progressed from the criteria additionally identified in the Standish-Kuon and Rice (2002) study. This meant that several initiatives did not meet the criteria exactly specified in the original study. Standish-Kuon and Rice (2002) originally defined *Business School* model initiatives as those developed by the business school with the initiative housed in the business school. In comparison, the research findings showed that *Business School* model initiatives were housed in the business school, but were developed either solely by the business school or by the business and engineering schools. Similarly, Standish-Kuon and Rice (2002) defined *Engineering School* model initiatives as those developed by the engineering and business schools with initiatives housed in the engineering school. The research findings revealed that initiatives following the *Engineering School* model were housed in the engineering school but were either developed by the engineering and business schools, or solely by the engineering school. In the case of *Multi-School* model initiatives, these were defined by Standish-Kuon and Rice (2002) as initiatives created by some of the schools in the institution – namely the business school, the engineering school, and one or more science or technical schools. However, in identifying initiatives developed by some of the schools of an institution, the findings revealed that

Multi-School model initiatives were developed mainly by the business and engineering schools and other schools at the institution, including either science/technical based schools or schools in areas such as architecture, arts and sciences, journalism, and political science. This demonstrated that the creation of *Multi-School* initiatives also involved schools outside business and science-based areas. As a result, to identify the model each initiative followed, it was essential that the initiative met the distinguishing criteria of one of the three models as outlined by Standish-Kuon and Rice (2002). In the case of *Business School* and *Engineering School* model initiatives, it was necessary to take both the schools involved in the initiatives' development and the home base into consideration. Simultaneously, to identify *Multi-School* model initiatives, it was necessary to identify initiatives that were created by some, not all, of the schools at an institution.

Some of the initiatives that were reviewed did not meet the distinguishing criteria of the *Business School*, *Engineering School*, or *Multi-School* models. This resulted in the addition of two models, which the initiatives were subsequently categorised into: the *External Partnership* and *Institution* models. The initiatives categorised as following the *External Partnership* model resulted from an institution's collaboration with external entities including networks, organisations, or other academic institutions. The initiatives following the *Institution* model were identified as being developed by either the institution or all the schools of an institution, as opposed to a select group of individual schools. In both cases, initiatives were found to be housed in different locations. In the case of the *External Partnership* model, initiatives were primarily housed in the engineering school but also in other locations such as the business school. For the *Institution* model, initiatives were primarily housed in freestanding entrepreneurship schools, but also in other locations such as the engineering school, the business school, or a combination of different schools at the institution.

At the end of the process, because of the differences in home bases amongst initiatives following each of the models, the home base could not be used to help categorise several of initiatives. The only exception where the home base was necessary was for initiatives that were developed by both the engineering and business schools. For these initiatives, the home base was essential to determining whether an initiative followed the *Business School* or *Engineering School* models. As a result, knowledge of the schools responsible for the development of the initiatives was essential to the categorisation of all initiatives reviewed in this research project. Using this approach, it was possible to address the issues where initiatives did not specifically meet the criteria specified by Standish-Kuon and Rice (2002). Consequently, criterion three was addressed.

7.2.4: Does the EEE typology have categories that are collectively exhaustive?

As explained by Hunt (1976, 2010), the fourth criterion is about whether or not every item classified had a "home". In this research context, this referred to whether each of the initiatives reviewed were able to be categorised into an EEE typology model. Overall, the classification process used in this research began with the three models identified in the Standish-Kuon and Rice (2002) study – the *Business School* model, the *Engineering School* model, and the *Multi-School* model. These models emerged based on data collected from the U.S.-based initiatives. As a result, the first phase of this research project looked at initiatives offered at U.S. institutions. Using the distinguishing characteristics described by Standish-Kuon and Rice (2002), the initiatives were reviewed and categorised according to the three original models. However, in reviewing the initiatives offered to engineering undergraduates at U.S. institutions, a group of initiatives were identified as not meeting the criteria pertaining to the three original models from the Standish-Kuon and Rice (2002) study. Given that these initiatives did not meet the criteria of the *Business School*, *Engineering School*, and *Multi-School* models, the findings ultimately showed that it was necessary to include two additional models in the typology. The model followed by initiatives that were developed by the engineering school, or the engineering and business schools, and organisations or networks external to the institution was named the *External Partnership* model. The model followed by initiatives that were developed by the institution or all schools in the institution for all undergraduates was named the *Institution* model. At the end of the first phase, a total of five models were identified based on initiatives offered to engineering undergraduates at U.S. institutions. Each of the U.S.-based initiatives, as a result, had a "home".

This new typology of models was then applied to the review of the initiatives offered to engineering undergraduates at institutions in Australia, Canada, New Zealand, and the

United Kingdom. This second phase of the research project was conducted not only to determine how engineering undergraduates were being educated about entrepreneurship in these four countries, but also to test for confirmation that the categories were collectively exhaustive. The findings first revealed that some of the models were present in each of the four countries. In Australia, for example, the initiatives were shown to either follow the *Engineering School*, *Business School*, or *Institution* models. In Canada, the initiatives followed either the *Engineering School*, *Business School*, or *External Partnership* models. In New Zealand and the United Kingdom, two models were found respectively – New Zealand initiatives followed either the *Engineering School* or *Business School* models, while U.K. initiatives followed either the *Engineering School* or *Institution* models. The findings collected from the non-U.S. data showed that of the five models found in the United States, four were present outside of the United States. As a result, no further models were needed to provide a "home" for entrepreneurship initiatives.

At the end of this process, each of the initiatives reviewed in this research project was categorised as following one of the five models of the EEE typology, which meant that each initiative had a "home". Based on this, the EEE typology addressed criterion four.

7.2.5: Is the EEE typology useful?

The final criterion of the Hunt (1976, 2010) criteria for classification schemata asked whether the typology adequately achieved its purpose. In this research context, the question was whether or not the EEE typology was useful. The "usefulness" with regards to the EEE typology is of three types, represented by the following three questions:

1. Is the EEE typology theoretically useful?
2. Is the EEE typology practically useful?
3. Is the EEE typology useful for future research?

The EEE typology describes Entrepreneurial Engineering education by showing not only the similarities and differences amongst the five models, but also the similarities and differences amongst the educational approaches used in each of the five countries examined. The presentation of the characteristics in the model descriptions highlighted which of the characteristics could be used for categorisation purposes and which of the characteristics could be used for descriptive purposes. Insight into the use of these characteristics is important and can be useful for other research areas. As a result, the identification of the usefulness of the EEE typology is necessary for determining how this typology can be used for future research purposes.

One of the areas that can be considered in the theoretical usefulness of the EEE typology is how this typology can be used to further understand entrepreneurial engineering. The characteristics of the models can be used as the foundation upon which other entrepreneurial engineering initiatives can be investigated at other levels. Academic researchers, for example, can use this typology to investigate how institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States are educating engineering students at the postgraduate level about entrepreneurship. To apply the typology in this context, the initiatives offered at the postgraduate level can be investigated by using the distinguishing characteristics and identifying the schools that were responsible for the development of the initiatives and, where applicable, the home base of the initiatives. The remaining characteristics can also be used to provide descriptions of the postgraduate initiatives.

The EEE typology was developed based on the entrepreneurship initiatives designed for engineering undergraduates at tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States. As a result, academic researchers can use the typology and the characteristics identified in this research project to investigate how additional countries are educating engineering undergraduates about entrepreneurship. Using information about the schools responsible for the development of the initiatives and the home base of the initiatives, researchers can determine whether or not the models from the EEE typology can be used to categorise initiatives in these countries to determine. This contributes to determining the generalizability the EEE typology and its five models.

In addition, the application of the EEE typology in countries other than the five examined in this research study may aid in the potential expansion of the EEE typology. Academic researchers can use the characteristics identified in this research project to highlight if there is any further variation amongst the models which will require additions to the EEE typology. The categorisation characteristics in particular – the schools responsible for the development of the initiatives and the home base of the initiatives – can help to determine whether or the not the EEE typology must be expanded to include new models.

The EEE typology can potentially be used in areas other than entrepreneurial engineering education. Academic researchers could use the typology as a foundation to launch investigations into how institutions educate undergraduates in other disciplines about entrepreneurship. The characteristics identified in this research project can be used as a measure to guide research into the models used to educate these students and, as a result, the categorisation of initiatives offered in these disciplines. This could potentially result in an extension of the use of the EEE typology, or ultimately lead to the development of new typologies that reflect each educational discipline.

The practical usefulness of the typology is a demonstration of how the EEE typology can be used by institutions to aid in the development of entrepreneurship education. As the typology provides information about how institutions are educating engineering undergraduates about entrepreneurship, top-level administrators at institutions can use this information to aid in decisions regarding ideas for future entrepreneurship initiatives for engineering undergraduates. For example, if institutions decide that they want initiatives to be developed for engineering undergraduates, they could decide that they want the engineering school to collaborate with the business school in developing an initiative, or they could want other schools to be involved in the collaboration. Using information about the different models that are available, and the schools that can be involved in initiative development, the administrators can see what is available and make the best selection based on the institutions' objectives and available resources.

With regards to the actual development of entrepreneurship initiatives, engineering school administrators and/or administrators from other schools could use this typology to develop new initiatives for engineering undergraduates. The descriptive characteristics identified in the EEE typology provide the characteristics that must be taken into consideration when designing future entrepreneurship initiatives. For example, if a decision was made to create an initiative that followed the *Engineering School* model, the developers of the initiative would have to decide whether the entrepreneurship courses offered would be taught in either the engineering school or the business school, and if the initiative would be designed specifically for engineering students or students from a variety of different disciplines. Furthermore, information from this typology can potentially be used to identify the methods and approaches that are most common in the educational systems of the five countries; or in the case of additional countries, the methods and approaches that are most common in educational systems similar to those of the five countries. As a result, the EEE typology provides the options that can be selected in order to structure and develop future initiatives.

As previously explained in section 6.3.1, the EEE typology was developed based on data collected from entrepreneurship initiatives offered at institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States. The findings also showed that not all institutions in each of these five countries offered entrepreneurship initiatives to their engineering undergraduates. If any of the remaining institutions expressed interest in the development of entrepreneurship initiatives for engineering undergraduates, the EEE typology could prove valuable. Top-Level administrators, for example, can use information about the types of educational programmes that are offered by the institutions in their countries. They can gain insight into the types of programmes that are most commonly offered in the institutions of their countries. Alternatively, this information can be used by the institutions as a point of differentiation to differentiate their courses from those of other institutions. From the EEE typology, the top-level administrators at Canadian universities, for example, can identify that the majority of Canadian initiatives offer short programmes in the form of entrepreneurship minors. As a result, in developing a new initiative for engineering undergraduates, administrators could decide whether to offer engineering courses that included entrepreneurial content rather than a minor. This will allow the institution to become “unique”, establishing itself as an alternative to the “norm”.

The EEE typology is also useful for the execution of future research. As explained, the typology describes how engineering undergraduates are educated about entrepreneurship in academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States. The description of the typology highlighted the characteristics of the models as well as which characteristics were useful for categorisation and description purposes. As shown in section 7.2.2, knowledge of the schools that developed the initiatives was essential to the categorisation of initiatives according to models. In addition, knowledge of the home base of the initiatives was important in the classification of some initiatives; specifically for initiatives following the *Business School* and *Engineering School* models that were developed by the engineering and business schools. In order to use this typology for future research, insight into these characteristics provides guidance into what is critical for the investigation of further entrepreneurship initiatives and how these initiatives can be assigned either to any of the models of the EEE typology or additional models.

Overall, the EEE typology was useful for theoretical, practical, and future research purposes. It identifies the characteristics that are necessary for the categorisation and description of entrepreneurship initiatives. It provides the necessary information that could be used by institutions interested in developing entrepreneurship initiatives for engineering undergraduates. This allows for more informed decisions to be made regarding types of initiatives, and subsequently the model, that will be the most suitable given available resources, institution goals, and educational curriculum structure. Furthermore, the contents of the typology can lay the foundation for future research studies in entrepreneurship education for engineering undergraduates. As a result, the usefulness of the EEE typology has addressed criterion five of Hunt's (1976, 2010) classification schemata.

7.3: Chapter Summary

The EEE typology was developed to determine and depict the models used by institutions to educate engineering undergraduates about entrepreneurship. This was developed based on data collected from entrepreneurship initiatives for engineering undergraduates at tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States. Using Hunt's (1976, 2010) criteria, the evaluation showed that the EEE typology meets all five criteria for acceptable classification schemata. This shows that the development of the EEE typology has made a valuable contribution to the research, theory, and practice with regards to entrepreneurship education and Entrepreneurial Engineering education.

The thesis concludes in the following, Chapter 8.

Chapter 8: Conclusion

8.1: Introduction

Chapter 8 contains the conclusion of this Ph.D. research project. First, it presents a restatement of the objectives and findings of the research, as well as the significance of the findings. It then discusses the strengths and limitations of the research, and ends with suggestions for future research.

8.2: The Research Summary and Findings

The purpose of this doctoral research study was to learn more about how Entrepreneurial Engineers were created, and tertiary-level academic institutions' role in this creation process. This research had three objectives:

1. To identify how tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States have addressed the need for engineering undergraduate students to develop entrepreneurial abilities;

2. To determine the typology developed based on the methods and approaches implemented and used by tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States to educate their engineering undergraduate students about entrepreneurship;

3. To determine the parameters and limitations of the proposed typology in terms of the typology's suitability for the classification of entrepreneurship initiatives used to create Entrepreneurial Engineers.

To acquire the necessary data to address these objectives, entrepreneurship education initiatives for engineering undergraduates offered at academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States were examined.

The study fulfilled the first research objective by examining the entrepreneurship initiatives for engineering undergraduates offered by tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States. The institutions selected had engineering programmes accredited by the main engineering accreditation boards in each of the five countries: Engineers Australia, Engineers Canada, IPENZ, Engineering Council U.K., and ABET. The findings revealed that five models or approaches are used to educate engineering undergraduates about entrepreneurship: the *Business School* model, the *Engineering School* model, the *Multi-School* model, the *External Partnership* model, and the *Institution* model, although all five models were not present in each of the five countries. Three of the models are used in Australia: the *Business School* model, the *Engineering School* model, and the *Institution* model. In Canada, three of the models are also used: the *Business School* model, the *Engineering School* model, and the *External Partnership* model. Two models were used in both New Zealand and the United Kingdom; in New Zealand, both the *Business School* and *Engineering School* models are used, while in the United Kingdom, both the *Engineering School* and *Institution* models are used. The United States was the only country where all five models were used.

The second research objective was achieved by first arranging the models identified into a typology, and then using the components of the Standish-Kuon and Rice (2002) typology, entrepreneurship education literature, and primary and secondary data to describe each of the models' components. The secondary data was collected from descriptions of entrepreneurship initiatives for engineering undergraduates available on the academic institutions' webpages, while the primary data was collected from questionnaires administered to engineering school administrators at these academic institutions. Based on the research study's findings, the five models were organised into a new typology which was named the Entrepreneurial Engineering Education, or EEE, typology. Each of the five models was described based on thirteen components – six presented in the Standish-Kuon and Rice (2002) typology and seven additional components. These components included:

1. The schools responsible for the development of the entrepreneurship initiatives;
2. The home base of the entrepreneurship initiatives;
3. The curriculum used in the entrepreneurship initiatives and the developers of the curriculum;
4. The target students of the entrepreneurship initiatives;
5. The location where the courses of the entrepreneurship initiatives are taught;

6. The faculty responsible for teaching the courses of the entrepreneurship initiatives;
7. The motivating factors behind the creation of the entrepreneurship initiatives;
8. The objectives of the entrepreneurship initiatives;
9. The types of educational programmes offered in the entrepreneurship initiatives;
10. The practical experiences offered in the entrepreneurship initiatives;
11. The competencies emphasised in the entrepreneurship initiatives;
12. The opportunities experienced in the entrepreneurship initiatives; and
13. The outcomes of the entrepreneurship initiatives.

The third and final research objective was achieved by evaluating the EEE typology's suitability for classifying entrepreneurship initiatives for engineering students using the Hunt (1976, 2010) criteria for acceptable classification schemata. The analysis of the EEE typology showed that the typology met all five of the criteria. First, the analysis showed that the unit of analysis used in this research study was each individual entrepreneurship initiative for engineering undergraduate students, and that the typology was formed based on the categorisation of these initiatives. This showed that the EEE typology addressed the first criterion regarding the identification of the unit of analysis for the research. Second, 13 components were reviewed and information gathered from these components was used to provide descriptions of each of the models of the EEE typology. Of the 13 components, *the schools responsible for the development of the entrepreneurship initiatives* was the component necessary for the categorisation of the entrepreneurship initiatives, with *the home base of the entrepreneurship initiatives* used an additional component to determine whether entrepreneurship initiatives developed by the business and engineering schools followed either the *Business School* or *Engineering School* models. The remaining components were used to describe the models, as opposed to classifying entrepreneurship initiatives. The distinguishing characteristics were used to classify each of the entrepreneurship initiatives included in this research study. As a result, the EEE typology addressed the second criterion, which focused on whether the characteristics needed for the classification were appropriate and consistently used. Third, the distinguishing characteristics identified in the Standish-Kuon and Rice (2002) study – *the schools responsible for the development of the entrepreneurship initiatives* and *the home base of the entrepreneurship initiatives* – were used to classify the entrepreneurship initiatives reviewed in this research study. The findings first showed that some of the entrepreneurship initiatives could not be categorised according to the models of the Standish-Kuon and Rice (2002) typology. This meant that additional models had to be added, resulting in the formation of a new typology – the EEE typology. The findings further revealed that *the schools responsible for the development of the entrepreneurship initiatives* was the only distinguishing characteristic that could be used due to the differences in home bases amongst initiatives following each of the EEE typology's models. The only exception was in the case of entrepreneurship initiatives developed by the business and engineering schools, where the home base was necessary to differentiate between the initiatives following the *Business School* and *Engineering School* models. Taking these findings into consideration was important in order to ensure that each initiative could fit into a model. As a result, the EEE typology addressed the third criterion, which focused on mutual exclusivity or, in other words, whether each of the items under research (entrepreneurship initiatives) fit into one category and no other (EEE typology model). Fourth, the EEE typology had five models, and this typology represented the growth in the presence and types of entrepreneurship initiatives used to educate engineering undergraduate students about entrepreneurship. To ensure that these models were representative of the entrepreneurship initiatives included in this research study, the initiative descriptions were examined to gather the relevant data about the schools responsible for developing the initiatives, and in the case of the initiatives developed by the business and engineering schools, the home base of the initiatives, in order to categorise each initiative according to the relevant model. The findings showed that the five models of the EEE typology were sufficient and represented the entrepreneurship initiatives reviewed, because each initiative could be categorised into one of the five models. Therefore, the EEE typology addressed the fourth criterion, which focused on whether each item categorised had a "home", which, in this research context, meant ensuring each entrepreneurship initiative could be categorised into an EEE typology model. Finally, the analysis showed that the EEE typology was useful in a number of different contexts. It was theoretically useful, where it outlines the components necessary for categorising and describing entrepreneurship initiatives, practically useful, where it presents information that can be used by academic institutions to develop entrepreneurship initiatives for engineering students, and useful for future research, where it presents opportunities for future research studies in entrepreneurship education for engineering students and entrepreneurship education for students in other disciplines to be conducted. This showed that the EEE typology addressed the final criterion by demonstrating its usefulness and the fact that it adequately achieved its purpose. Meeting each of the Hunt (1976, 2010) criteria meant that the EEE typology is suitable for classifying entrepreneurship initiatives for engineering students.

The findings obtained from this research enhance our understanding of entrepreneurship education for engineering undergraduates – more specifically how tertiary-level academic institutions are creating a new cohort of entrepreneurial engineers. The current findings add to a growing body of literature of Entrepreneurial Engineering and entrepreneurship education for engineering students, which therefore can aid in the knowledge of entrepreneurial engineer creation process. As a result, this research and its associated findings have created a platform from which future research studies in Entrepreneurial Engineering, and entrepreneurship education in engineering and other academic disciplines can be launched.

8.3: The Strengths and Limitations of the Research

A number of strengths and limitations of the research were recognised and acknowledged. These strengths and limitations were associated with the research design, research method, and the population examined. This section discusses the strengths and limitations that were identified in the execution of the research.

8.3.1: The strengths and limitations of the Research Design

The research was designed in order to gather the data necessary to gain a deeper understanding of entrepreneurship education for engineering undergraduates, and determine the models used by institutions to educate engineering undergraduates about entrepreneurship. The decision was therefore made to employ a mixed methods research approach, which combined qualitative data, in the form of secondary data collected from entrepreneurship initiative descriptions on academic institution webpages, with quantitative data, in the form of primary data collected from questionnaires.

Mixed methods research, compared to the solely qualitative and quantitative research approaches, are more in line with human nature; making it an ideal research approach because people generally use mixed methods to understand the world (Creswell & Plano Clark 2011). Using mixed methods research opens the door to a wider assortment of data and analysis tools, both quantitative and qualitative, which is able to give support, provide more evidence for studying a research problem, and potentially enhance what is learned about a particular research topic (Creswell & Plano Clark 2011). As a result, the use of a mixed methods approach allowed for a combination of the strengths of both qualitative and quantitative studies (O'Leary 2014). Furthermore, the use of multiple strategies enabled the investigation of a research topic from different perspectives which allowed for the presentation of a broader picture of the area which was being investigated (Henn et al. 2006; O'Leary 2014). To paint this picture, a mixed methods approach allowed for the collection of both qualitative and quantitative data, which allowed for more comprehensive results being produced (Sarantakos 2013). For this research study, employing a mixed methods approach allowed for a picture of the face of entrepreneurship education for engineering undergraduates to be portrayed. In this context, collecting data from both institution websites and online questionnaires allowed for the acquisition of data from different perspectives which demonstrated how tertiary-level academic institutions are educating engineering undergraduates to be entrepreneurial. In addition, both qualitative and quantitative data were necessary in order to address the research questions used in this study. This further supported the use of a mixed methods approach given that these types of studies are not only more powerful than single research approaches (Sarantakos 2013), but also use all available and suitable methods to provide answers to research questions that are unable to be answered by either qualitative or quantitative approaches alone (Creswell & Plano Clark 2011).

The mixed methods research approach also enabled a deeper understanding of the research problem to be developed (Creswell 2015). The research problem itself had multiple objectives, and to address these objectives, a study with multiple phases was required. The decision was made to design the research into three phases – the first two being qualitative and the final phase being quantitative. This was because the identification of the qualitative data resulted in the awareness of the available data, and subsequently the data that needed to be further acquired (Creswell 2015). By using a mixed methods approach, it was possible to identify the data that was present, the gaps in the data that needed to be filled, and ultimately the areas that needed to be addressed in future studies. As a result, a mixed methods study was appropriate given that it is suited to research problems where overall research objectives are best addressed with multiple phases or projects (Creswell & Plano Clark 2011).

As previously explained, the mixed methods design used in this research study was executed in three phases. The first two phases of the research study were qualitative and used to identify current information regarding entrepreneurship education for engineering undergraduates. The third phase of the research project, on the other hand, was quantitative. The first two phases of the research study laid the foundation for the third phase. They provided insight into the further information that was required for this research project. To obtain this information, a self-completion questionnaire was administered online with links sent to engineering school administrators asking them to provide the required data. As a result, the first two phases (qualitative), which were used to identify current information regarding entrepreneurship education for engineering undergraduates, also provided a structure for the third phase of the research (quantitative). They provided insight into further information that was required to present descriptions of the models for educating engineering undergraduates about entrepreneurship. The data collected from all three phases were then combined to present details about each of the models of the EEE typology. Taking into consideration the absence of extensive data about how institutions educate engineering undergraduates about entrepreneurship, the employment of a Mixed Methods research design proved the best approach for this research. The qualitative component of the research provided information that the quantitative component could not; and vice-versa. Despite the fact that some purists believe that quantitative and qualitative research are separate and cannot be combined (Bryman & Bell 2011; Onwuegbuzie 2012), it is generally accepted that both types can be combined (Onwuegbuzie 2012). As a result, the use of both a qualitative and a quantitative component proved necessary to present a complete description of each of the models of the EEE typology.

8.3.2: The strengths and limitations of the Research Method: Data Collection

In this research study, secondary data was collected in Phase One and Two, and primary data was collected in Phase Three. As explained in section 4.4, the secondary data used in this research was acquired from the internet – a desktop review was conducted of entrepreneurship initiatives for engineering undergraduates on the websites of tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States. The data was collected from online descriptions of the entrepreneurship initiatives, as well as other sources included course catalogues, programme pamphlets and brochures, and other institutions documents that were available in adobe PDF format on the websites.

The use of secondary data was beneficial to this research. Secondary data is relatively inexpensive to use, requires limited resources, and generally is not time-consuming to gather (Hair et al. 2011; Lancaster 2005; O'Leary 2014; Polonsky & Waller 2011; Saunders et al. 2007; Wilson 2010). These were some of the advantages that were gained from using secondary data. The examination of secondary data allows for background information of a particular topic to emerge (Polonsky & Waller 2011), as a result, the review of secondary data cam potentially result in the emergence of new insights into a topic (Hair et al. 2011). This occurred in this research where the gathering and review of the data highlighted the presence of two new models and the roles played by the various characteristics of the models that were examined. The use of entrepreneurship initiative website descriptions was suitable, particularly given the time constraints of this research. It presented the information that was previously collected and readily available, which eliminated the need to gather and analyse additional raw data.

However, it was recognised that the sole use of secondary data was insufficient for the research. In reviewing the available data present on the websites, it was revealed that this data did not contain all of the details regarding entrepreneurship education for engineering undergraduates that was desired for this study. The literature shows that secondary data has a number of disadvantages, however in the context of this research the main limitation which had to be considered was the fact that any secondary data examined would have been collected for other purposes, which resulted in the available data not possessing all the required information to address research problems and objectives (Hair et al. 2011; Lancaster 2005; Polonsky & Waller 2011; Saunders et al. 2007). This, as a result, meant that it was necessary to collect primary data.

Primary data, as previously explained in section 4.4, was the data collected by the researcher for the specific purposes of the study. The type of primary data collected is dependent on the purposes of the research and is therefore custom-built according to the desires of the researcher (O'Leary 2014; Wilson 2010). In this research, the inclusion of primary data on the third phase of the study addressed the gaps in the information that emerged during the review of the second data in the first two phases. As explained in section 4.4, online questionnaires were used to collect data in the third phase of the research study. This questionnaire was designed specifically for engineering school administrator to provide information about entrepreneurship initiatives offered to engineering undergraduates at their institutions. It was administered online using Survey Monkey and a link to the questionnaire was emailed to engineering school administrators. A strength of this approach was that the use of online questionnaires removed the costs associated with posting paper questionnaires to institutions in the five countries. It also addressed the time sensitivity issue by reducing the amount of time it would take to post and receive paper questionnaires. Furthermore, the use of online questionnaires removed a step from the data analysis process by eliminating the time it would have taken to enter the data electronically for analysis purposes.

There were, however, limitations to the collection of primary data and the use of online questionnaires experienced in this research, which were comparative to the limitations identified in the literature. For example, the collection of primary data is generally time-consuming, potentially expensive, and may not always go according to the originally intended plan (O'Leary 2014; Wilson 2010). In this research, in comparison to the free collection of the secondary data from institution websites, expenses were somewhat incurred to obtain the primary data through the questionnaires. The main costs that were involved included the subscription fee associated with Survey Monkey, as well as the costs associated with the translation of the survey into French so that it could be sent to francophone institutions in Canada, the translation of the survey again into English to ensure quality and understanding of the survey, and finally the translation of the open-ended answers received from the francophone institutions.

There were also limitations attached to the use of online questionnaires. The major limitation experienced in this research was the difficulty in obtaining large numbers of respondents. There is a potential for online questionnaires to yield low response rates (Bryman & Bell 2011). Despite a 21% response rate being acceptable, it was difficult to obtain a greater number despite extensive attempts. Reflecting on this occurrence, it may have been ideal to find a way to motivate potential respondents to complete to the questionnaire using some form of motivation. Another limitation associated with the use of questionnaires included the difficulty that researchers face in asking too many questions on a questionnaire (Bryman & Bell 2011). Although more questions could have been posed, there was a fear that potential respondents would be deterred from completing the questionnaire. A third limitation was the difficult faced in asking additional follow-up questions (Bryman & Bell 2011). This was particularly in cases where elaboration of responses was desired. This, as a result, limited the collection of additional data. Finally, questionnaires generally have a greater risk of missing data (Bryman & Bell 2011). There were instances where some questionnaire responses had missing data due to the fact that respondents could elect to answer the questions posed. The decision to make each question optional was to deter potential respondents from choosing to complete the questionnaire. This resulted in a reduced presence of information in certain areas that were covered in the questionnaire.

A higher response rate may have provided further details and helped to identify additional trends relating to how tertiary-level academic institutions were educating their engineering undergraduates were learning about entrepreneurship. However, the responses that were received still provided valuable information which helped to achieve the purpose of the EEE typology development.

As a result, the use of a desktop review in addition to an online questionnaire enabled information to be gathered from available entrepreneurship initiatives for engineering undergraduates as well as identify the data that was additionally needed in order to present information about the models used by the institutions. However, it first and foremost facilitated the collection of both primary and secondary data. This allowed for both new and available data to be combined in order to present a broad picture of the entrepreneurial education of engineering undergraduates.

8.3.3: The strengths and limitations of the Research Method: Data Analysis

As explained in section 4.4, this research study was designed as a multi-phase study consisting of three phases. The first two phases were qualitative and involved the collection of secondary data acquired from institution websites, while the final phase was quantitative and involved the collection of primary data through the use of online questionnaires. As a result, this required two different data analyses to be performed.

The secondary data was analysed using a Content Analysis. A Content Analysis is a method or technique where either a qualitative or quantitative analysis, or both a qualitative and quantitative analysis, is done in order to examine the content of various forms of written, visual, or verbal materials (Babbie 2014; Bouma & Ling 2004; Sarantakos 2013). This form of analysis first involves determining the unit of analysis, which is the individual unit (or units) of analysis about which descriptive and explanatory statements are made; and then conducting a coding process, where the data obtained is either coded or classified according to a conceptual framework (Babbie 2014). In this research, each individual entrepreneurship initiative was considered the unit of analysis, and the information taken from each initiative description on the institutions' webpages was entered into excel spreadsheets and placed in columns representing the types of information collected. In Phase One of the research, which was focused on the entrepreneurship initiatives offered by tertiary-level academic institutions in the United States, the organisation of the data was done manually. The relevant information identified in the data were classified according to the Standish-Kuon and Rice (2002) typology using the schools responsible for the development of the initiatives and the home base of the initiatives as the basis for categorisation into respective models.

In the Phase Two, Excel spreadsheets were also created to organise the data that was collected from institutions in Australia, Canada, New Zealand, and the United Kingdom. However, in order to compare different methods, the decision was made to analyse the data collected using N-Vivo computer analytical software as opposed to manually. N-Vivo software helps to make the analysis process easier and less time-consuming, and aids in the coding, reduction, and interpretation of data (Wilson 2010). In addition, N-Vivo enables data and ideas to be more organised (Bazeley 2007), and helps to reduce the initial preparation work which ultimately produces results at a much faster rate and provides easier access to all data (Sarantakos 2013). To use the N-Vivo process, data collected from the webpages were also arranged in Microsoft word documents for import into the software program. Reflection on this analysis process showed that the benefits associated with N-Vivo identified in the research literature were all realised in this research. However, it was noted that the initial creation of nodes and other folders in N-Vivo was easier because of the fact that data was originally organised into the Excel spreadsheets. N-Vivo therefore was used to not only analyse data but also served as a way to confirm that the data was entered correctly into the Excel spreadsheets. As a result, although the results were obtained without the use of N-Vivo, as in the case of Phase One, N-Vivo made the analytical process not only easier, but also more efficient because it facilitated the confirmation of the information that was gathered from the collected data. Furthermore, because the Content Analysis process enabled the organisation of collected data, the organisation helped to identify which data was present, and subsequently which data was missing and therefore required. Therefore, conducting a Content Analysis in the first two phases of the research study not only allowed for the classification of entrepreneurship initiatives according to the models and identification of relevant data, but also facilitated the analysis of the quantitative data because of the ability to group the respondents according to the models.

The primary data collected from the online questionnaires was analysed using the SPSS program for Windows version 22 and Microsoft Excel 2013. As explained in section 4.4, the online questionnaire was administered through the Survey Monkey platform. Invitations containing links to the surveys were then emailed to potential respondents in the five countries included in this research. Using Survey Monkey made the data preparation for import into SPSS and Microsoft Excel easier. This was because it was possible to download the individual and collective responses in an Excel spreadsheet, which then simply had to be edited for analysis. If paper or postal questionnaires had been used, the collected response data would have had to be manually entered into these spreadsheets before analysis could be performed. As a result, the analysis process was considerably shortened. Furthermore, the use of SPSS and Microsoft Excel produced figures and diagrams which helped to enhance the interpretation and analysis of the data.

Three statistical analyses were performed on the primary data: descriptive statistics, cross-tabulations, and factor analyses. Descriptive statistics were used to provide a summarising number to illustrate what was typical for the data (Rea & Parker 2014). These statistics helped to provide information regarding entrepreneurship education for engineering undergraduates. However, it was insufficient to compare and contrast, and ultimately describe, the characteristics of the models of the EEE typology. To address these issues, cross-tabulations were used. Cross-tabulations show the influence of one variable on another and show the differences that exist in the topics being discussed (Rea & Parker 2014). In the context of this study, the cross-tabulations helped to compare the five models according to the 13 characteristics identified. This shows that descriptive statistics and cross-tabulations served two purposes – to describe entrepreneurship education for engineering undergraduates and to compare the models of the EEE typology – with cross-tabulations addressing the limitation of the descriptive statistics. The factor analysis was also important to this study. A factor analysis is used to develop theoretical constructs associated with a particular topic, as well as to identify leads that in turn can be used to suggest future areas of study (Gorsuch 2014). In the context of this study, the use of the factor analysis identified the entrepreneurial competencies that engineering school administrators believed were necessary for engineering undergraduates to possess. The limitation of factor analysis associated with this study was the fact that a small sample size could generate different results across different studies (McNemar 1951). Given the respondent sample size for this particular topic, it is possible that a replication of the study with a larger and different sample may generate other entrepreneurial competencies. However, the findings obtained in this study produced a theoretical base which could be used to carry out future studies in the entrepreneurial competencies for engineering students.

8.3.4: The strengths and limitations of the Research Population

The population for this research study, as outlined in section 4.4, consisted of tertiary-level academic institutions with undergraduate engineering programmes accredited by the main engineering boards in Australia, Canada, New Zealand, the United Kingdom, and the United States that offered entrepreneurship initiatives to engineering undergraduates.

These five countries were valuable to the research. The United States was where the original Standish-Kuon and Rice (2002) was conducted and this, as a result, influenced the decision to examine entrepreneurship initiatives for engineering undergraduates in the United States during the first phase of the research. In addition, the United States was the most entrepreneurial country based on the Global Entrepreneurship Index list (Acs et al. 2016). Australia, Canada, and the United Kingdom were also included due to the fact that these countries, in addition to the United States, were the most entrepreneurial English-speaking countries, ranking second (Canada), third (Australia), and ninth (the United Kingdom) on the current Global Entrepreneurship Index list (Acs et al. 2016). New Zealand was also included in the research due to the fact that it is an entrepreneurial country that focuses on the creation and development of entrepreneurs, and due to its close proximity and relationship with Australia and the Asia-Pacific region. It was recognised that the findings from the research could not be generalised. The absence of data from other countries meant that it was impossible to determine if these findings were representative of the ways in which tertiary-level academic institutions in other countries were educating their engineering undergraduates to be entrepreneurial. However, the findings from this research created a platform where investigations into the activities occurring in other countries could be launched.

The questionnaire used in this research was designed to acquire data from deans and other administrative officers at the institutions. Valuable data was collected which enabled comparisons amongst the different models to be made. However, there is the possibility that if other groups of individuals were additionally surveyed, further insight could have been gained into how the models compared to each other. For example, if educators who teach the courses in the entrepreneurship initiatives were surveyed, further insight could have been gained regarding course content, teaching or pedagogical methods employed, and feedback on these based on the results that have been achieved. If students, for example, were surveyed it may have been possible to determine whether students were achieving the intended outcomes of the initiatives, which could have resulted in comparisons being made amongst the models. This would have then provided another area or characteristic upon which the models of the EEE typology could have been differentiated. In addition, a major limitation was that there were few questionnaire responses for each of the five models in comparison to the total offering initiatives following each model. This, as a result, impacted the ability to determine if the views received were representative of others whose initiatives followed the same model, and others whose initiatives followed the same model in the same country.

The EEE typology that resulted from this research described how academic institutions in the five countries educated their engineering undergraduates about entrepreneurship. It was best to focus on the activities in five countries due to time constraints and valuable information was gathered. However, in order to generalise this typology and determine its applicability to entrepreneurship initiatives for engineering undergraduates in other countries, further research will be necessary to investigate if other methods or approaches are being used. In addition, surveying other groups at these institutions could provide even greater insight into the approaches taken, as well as into the effectiveness of these approaches as gauged by student outcomes. As a result, this typology lays a foundation that facilitates the occurrence of future research.

8.4: Suggestions for Future Research Studies

The reflection on the research design, research method, and population used provides important insight which must be considered for future research studies. To do research on entrepreneurship initiatives for engineering undergraduates, or students in any other discipline, this research demonstrated that a Mixed Methods design was the most appropriate for presenting a picture of the structures of initiatives. Although the analysis of entrepreneurship initiatives using the content available on institution webpages provided valuable insight, particularly given the time constraints attached to the research, a longer research study with a greater level of funding could involve additional approaches to acquire further information. Besides the analysis of webpage content, these approaches could include, for example, interviews with engineering school administrators or faculty members involved with entrepreneurship initiatives, field visits to institutions to get first hand views and make observations about the initiatives, or the establishment focus groups consisting of relevant people who could provide useful insight into what should be investigated with regards to entrepreneurship initiatives. Despite the low but acceptable response rate, the use of questionnaires also proved valuable. As a result, in future research, it may be best to provide an incentive that can stimulate higher response levels. The incentives could be in any form that will be meaningful to either respondents or institutions, ranging from donations to the institution or charitable organisations to gift cards for respondents. Furthermore, for future research studies, it would be ideal to apply these additional approaches to determine if different findings regarding entrepreneurship initiatives in Australia, Canada, New Zealand, the United Kingdom, and the United States, would emerge. The approaches could also be applied to the investigation of entrepreneurship initiatives for engineering undergraduates in other countries. As a result, from this research, appropriate research designs and methods were identified which could serve to achieve the best results for studies investigating entrepreneurship education for engineering students.

Future research opportunities were also identified in the literature reviewed for this study. First, two areas discussed in the Standish-Kuon and Rice (2002) were the goals for the entrepreneurship initiatives at the six universities examined, and the factors that enhanced or inhibited the development of these initiatives. Neither of these was investigated in this research study and therefore could be investigated in future studies using the entrepreneurship initiatives examined in this study. Second, Standish-Kuon and Rice (2002) stated that five categories of actions were used to generally define entrepreneurship education: 1) developing intellectual content, including scholarly research; 2) gaining institutional acceptance, with attention to curricular, structural, and fiscal issues; 3) engaging students and alumni; 4) building relationships with the business community; and 5) showcasing success. The authors further stated that these categories were used as the framework to conceptualise the models of the Standish-Kuon and Rice (2002) typology; despite the fact that, as stated in 2017 by co-author Mark P. Rice, it is not clear that the five categories were used in the final conceptualisation of the three models. A future research study can therefore analyse the EEE typology according to these five categories. Third, the two distinguishing characteristics of the models of the Standish-Kuon and Rice (2002) typology – *the schools responsible for the development of the entrepreneurship initiatives* and *the home base of the entrepreneurship initiatives* – are critical to success. Standish-Kuon and Rice (2002) stated that the responses to the survey they administered to identify the factors that influenced the direction of technological entrepreneurship initiatives revealed that four important factors were essential to the development of technological entrepreneurship initiatives and overall success. The authors additionally stated that their typology was connected to these four factors of success. These four factors were: 1) championing by the entrepreneurship center director; 2) sufficient quality of courses; 3) championing by alumni and current students; and 4) using entrepreneurs as guest lecturers/mentors. These factors highlight the importance of these two distinguishing characteristics. For example, in the case of the home base, the first factor is important because of the need for institutional champions (for example deans, department heads, and entrepreneurship directors) to deal with institutional issues such as promoting collaborating among entrepreneurship and non-entrepreneurship faculty. In the case of the schools responsible, this factor is critical, for example, because of the need for academics and expert practitioners who are involved to ensure that courses are of sufficient quality. This study did not focus on connecting the EEE typology to factors of success and, as a result, this could be the objective of a future research study. Finally, as discussed in section 3.2, tertiary-level academic institutions play an important role in the creation of an environment and development of an organisational culture that facilitates the teaching of entrepreneurship. This demonstrates the importance of researching the development of university-based entrepreneurship ecosystems. Future research studies can explore, for example, the entrepreneurship ecosystems that universities and other tertiary-level academic institutions have developed to support and facilitate the presence of entrepreneurship education in engineering and other academic disciplines, the effects that entrepreneurship ecosystems have on students' entrepreneurial intentions, and the types of ecosystem designs being used and the type that is the most effective for developing entrepreneurial capabilities and intentions among the students.

This doctoral research, and in particular, the EEE typology, has presented a number of opportunities which can be undertaken in future research projects. As explained, the EEE typology was developed to show how tertiary-level academic institutions in Australia, Canada, New Zealand, the United Kingdom, and the United States educate engineering undergraduates about entrepreneurship. Future research could therefore concentrate on the use of the EEE typology to investigate how academic institutions in other countries are educating their engineering undergraduates to be entrepreneurial. Furthermore, given the growth in entrepreneurship education for non-business students, a study involving the use of the EEE typology to investigate how undergraduate students pursuing other non-business degrees learn about entrepreneurship has also become a necessity. Future research into how engineering and other non-business students learn about entrepreneurship at the postgraduate level could also be of valuable interest. Despite the extensive research that has occurred into entrepreneurship education in business schools, a study examining how institutions educate undergraduate and postgraduate business students about entrepreneurship could be of interest. These studies will add to the overall understanding of how tertiary-level academic institutions educate students in all disciplines and at all levels about entrepreneurship. Consequently, if the typology were to be applied to other countries, academic disciplines, or educational levels, it could potentially result in the expansion of the typology, or the subsequent tailoring of the typology to reflect how entrepreneurship education occurs. Therefore, the EEE typology could be used as a measure for the exploration of other entrepreneurship initiatives.

The descriptions of the models of the EEE typology presented information about the types of entrepreneurship educational programmes that are offered in entrepreneurship initiatives for engineering undergraduates. The research findings revealed that entrepreneurship initiatives for engineering undergraduates offered entrepreneurship-based bachelor degree programmes, short entrepreneurship programmes, entrepreneurship experiential or practical learning programmes, individual entrepreneurship courses, or individual entrepreneurial engineering courses and projects. As suggested in the case of the *Business School* model, the findings related to the types of educational programmes used in *Engineering School* model entrepreneurship could also be the result of the way in which engineering degrees are structured within the five countries.

In addition, the type of educational programme used could have been selected based on the personal goals of the institution. However, determining why institutions selected certain programmes was not one of the objectives of this research. Therefore, more insight into this programme selection is of important interest. Research is required as to the factors that influence institutions' selection of certain programmes as opposed to others. In addition, future research might investigate and compare the effects of each type of programme, with regards to students and their acquisition and demonstration of entrepreneurial competencies. In line with this, future research could assess the overall outcomes of the EEE typology's models. Such research projects can be focused on students' attainment of entrepreneurial abilities, as well as their demonstration of entrepreneurial competencies. The identification of programme selection could potentially play a role in the examination of the outcomes. The EEE typology models' descriptions show the characteristics that can be used to categorise initiatives, in addition to the characteristics that could be used to describe the models. Awareness of these characteristics is valuable; it provides insight into the characteristics that have been explored. Future research projects can focus on taking the classification characteristics and applying them to other initiatives in order to determine if there are other models in existence. Stemming from this, future work needs to be done to potentially identify additional characteristics that can either classify initiatives or describe the models.

The findings further revealed that the models of the EEE typology had the same objectives and outcomes. Future research should be done to establish whether the objectives and outcomes of each model are aligned. This could provide insight into how the models work in achieving their educational goals of producing Entrepreneurial Engineers. A further study could examine the learning outcomes achieved by engineering students who participate in entrepreneurship initiatives. More specifically, this research project can focus on whether the model that is used affects student outcomes. This would involve comparing and contrasting of the educational outcomes of schools following each model in order to determine if the model used produces different outcomes for students.

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Appendices

Appendix One: The Tertiary-Level Academic Institutions included in the Phase One Sample

U.S. Tertiary-Level Academic Institutions included in the Phase One Sample

1. Arizona State University
2. Baylor University
3. Boston University
4. Bucknell University
5. California State University, Fullerton
6. California State University, Long Beach
7. Carnegie Melon University
8. Case Western University
9. Clarkson University
10. Columbia University
11. Cornell University
12. Dartmouth College
13. Drexel University
14. Duke University
15. Ferris State University
16. Florida International University (Modesto Maidique Campus)
17. Florida State University
18. Fort Lewis College
19. Franklin W. Olin College of Engineering
20. George Mason University
21. Georgia Institute of Technology
22. Gonzaga University
23. Grand Valley State University
24. Grove City College
25. Hofstra University
26. Illinois Institute of Technology
27. Iowa State University
28. Jackson State University
29. James Madison University
30. Kansas State University
31. Kettering University
32. Lawrence Technological University
33. Lehigh University
34. Lipscomb University
35. Louisiana Tech University
36. Loyola University Maryland
37. Marquette University
38. Marshall University
39. Massachusetts Institute of Technology
40. Mercer University
41. Miami University
42. Michigan Technology University
43. Midwestern State University
44. Milwaukee School of Engineering

45. Mississippi State University
46. Montana State University – Bozeman
47. Morgan State University
48. New Jersey Institute of Technology
49. New York Institute of Technology
50. New York University Polytechnic School of Engineering
51. Norfolk State University
52. North Carolina Agricultural and Technical State University
53. North Carolina State University at Raleigh
54. North Dakota State University
55. Northeastern University
56. Northwestern University
57. Northern Arizona University
58. Northern Illinois University
59. Oakland University
60. Ohio Northern University
61. Ohio University
62. Oklahoma Christian University
63. Old Dominion University
64. Oregon State University
65. Pennsylvania State University
66. Princeton University
67. Purdue University at West Lafayette
68. Rensselaer Polytechnic Institute
69. Rochester Institute of Technology
70. Rose-Hulman Institute of Technology
71. Rutgers, The State University of New Jersey
72. Saginaw Valley State University
73. Saint Louis University
74. San Diego State University
75. San Jose State University
76. Santa Clara University
77. Seattle Pacific University
78. Seattle University
79. South Dakota State University
80. Southeast Missouri State University
81. Southern Illinois University Carbondale
82. Southern Methodist University
83. Southern Polytechnic State University (Kennesaw State University)
84. St Cloud State University
85. St Mary's University (Texas)
86. Stanford University
87. Stevens Institute of Technology
88. Stony Brook University (The State University of New York at Stony Brook)
89. Swarthmore College
90. Syracuse University
91. Tarleton State University
92. Taylor University
93. Temple University
94. Tennessee State University
95. Texas Christian University
96. Texas Tech University
97. The Catholic University of America

98. The College of New Jersey
99. The George Washington University
100. The Johns Hopkins University
101. The Ohio State University
102. The University of Akron
103. The University of Alabama in Huntsville
104. The University of Memphis
105. The University of Texas – Pan American
106. The University of Texas at San Antonio
107. The University of Toledo
108. The University of Tulsa
109. Trine University
110. Tufts University
111. Tulane University
112. Union College
113. University of Alabama at Birmingham
114. University of Arizona
115. University of Arkansas at Little Rock
116. University of California, Berkeley
117. University of California, Davis
118. University of California, Los Angeles
119. University of California, San Diego
120. University of Central Florida
121. University of Cincinnati
122. University of Colorado at Boulder
123. University of Colorado at Colorado Springs
124. University of Colorado at Denver
125. University of Connecticut
126. University of Dayton
127. University of Delaware
128. University of Denver
129. University of Detroit Mercy
130. University of Evansville
131. University of Florida
132. University of Georgia
133. University of Hartford
134. University of Houston
135. University of Idaho
136. University of Illinois at Urbana-Champaign
137. University of Iowa
138. University of Louisiana at Lafayette
139. University of Maine
140. University of Maryland, College Park
141. University of Massachusetts Lowell
142. University of Miami
143. University of Michigan
144. University of Mississippi
145. University of Missouri – Kansas City
146. University of Nevada, Las Vegas
147. University of Nevada, Reno
148. University of New Haven
149. University of New Orleans
150. University of North Dakota
151. University of North Florida

152. University of North Texas
153. University of Notre Dame
154. University of Oklahoma
155. University of Pennsylvania
156. University of Portland
157. University of Puerto Rico, Mayagüez Campus
158. University of Rochester
159. University of South Alabama
160. University of South Florida
161. University of Southern California
162. University of Southern Indiana
163. University of St Thomas (Minnesota)
164. University of Tennessee at Chattanooga
165. University of Tennessee at Knoxville
166. University of Tennessee at Martin
167. University of Texas at Dallas
168. University of Texas at El Paso
169. University of Texas at Tyler
170. University of Texas of the Permian Basis
171. University of the District of Columbia
172. University of Turabo
173. University of Utah
174. University of Vermont
175. University of Virginia
176. University of Washington Bothell
177. University of Washington Seattle
178. University of Wisconsin – Madison
179. University of Wisconsin – Milwaukee
180. University of Wisconsin – Platteville
181. University of Wyoming
182. Utah State University
183. Vanderbilt University
184. Villanova University
185. Virginia Commonwealth University
186. Virginia Polytechnic Institute and State University (Virginia Tech)
187. Washington State University
188. Washington University
189. Wayne State University
190. Webb Institute
191. Wentworth Institute of Technology
192. West Virginia University
193. Western Carolina University
194. Western Illinois University
195. Western Kentucky University
196. Western Michigan University
197. Western New England University
198. Wichita State University
199. Widener University
200. Wilkes University
201. Worcester Polytechnic Institute
202. York College of Pennsylvania
203. Youngstown State University

Appendix Two: The Tertiary-Level Academic Institutions included in the Phase Two Sample

A: Australia Tertiary-Level Academic Institutions included in the Phase Two Sample

1. Australian National University
2. Edith Cowan University
3. Flinders University
4. Macquarie University
5. Queensland University of Technology
6. RMIT (Royal Melbourne Institute of Technology)
7. Swinburne University of Technology
8. The University of Canberra
9. The University of Newcastle
10. The University of Queensland
11. The University of South Australia
12. The University of Technology, Sydney
13. The University of Wollongong

B: Canadian Tertiary-Level Academic Institutions included in the Phase Two Sample

1. Carleton University
2. Concordia University
3. École de technologie supérieure
4. École Polytechnique de Montréal
5. Lakehead University
6. McGill University
7. McMaster University
8. Memorial University of Newfoundland
9. Ryerson University
10. Simon Fraser University
11. The University of Calgary
12. Université de Sherbrooke
13. University of Alberta
14. University of British Columbia
15. University of Manitoba
16. University of New Brunswick
17. University of Northern British Columbia
18. University of Ontario Institute of Technology
19. University of Ottawa
20. University of Saskatchewan
21. University of Toronto
22. University of Victoria
23. University of Waterloo
24. University of Western Ontario

C: New Zealand Tertiary-Level Academic Institutions included in the Phase Two Sample

1. Massey University
2. University of Auckland
3. University of Canterbury
4. University of Waikato
5. Victoria University of Wellington

D: U.K. Tertiary-Level Academic Institutions included in the Phase Two Sample

1. Buckinghamshire New University
2. City University London
3. Glyndŵr University
4. Heriot-Watt University
5. Imperial College London
6. Kingston University
7. Lancaster University
8. London South Bank University
9. Loughborough University
10. Newcastle University
11. Queen Mary University of London
12. Southampton Solent University
13. Staffordshire University
14. Swansea University
15. Teesside University
16. University of Bath
17. University of Birmingham
18. University of Brighton
19. University of Cambridge
20. University of Dundee
21. University of East Anglia
22. University of Greenwich
23. University of Hertfordshire
24. University of Huddersfield
25. University of London (University College of London)
26. University of Manchester
27. University of Nottingham
28. University of Reading
29. University of Sheffield
30. University of Southampton
31. University of Strathclyde
32. University of Ulster [Ulster University]
33. University of Wales, Trinity Saint David
34. University of Warwick
35. University of Wolverhampton
36. University of York

Appendix Three: The N-Vivo Coding Rules

This Appendix presents the coding rules that were used to code the data collected from entrepreneurship initiatives for engineering undergraduates offered at tertiary-level academic institutions in Australia, Canada, New Zealand, and the United Kingdom included in the Phase Two sample.

A four-level node hierarchy was created in the N-Vivo project. The nodes of the first level – i.e. the Level One or Parent Nodes – were named after each of the models identified in Phase One of the research study.

Level One Nodes [Parent Nodes]

Node Name	Coding Rule
Business School Model	Information about the components of the *Business School* model based on details acquired about entrepreneurship initiatives from institutions that follow this model.
Engineering School Model	Information about the components of the *Engineering School* model based on details acquired about entrepreneurship initiatives from institutions that follow this model.
External Partnership Model	Information about the components of the *External Partnership* model based on details acquired about entrepreneurship initiatives from institutions that follow this model.
Institution Model	Information about the components of the *Institution* model based on details acquired about entrepreneurship initiatives from institutions that follow this model.
Multi-School Model	Information about the components of the *Multi-School* model based on details acquired about entrepreneurship initiatives from institutions that follow this model.

A further three-level node hierarchy – i.e. the Child, Grandchild, and Great-Grandchild nodes – was placed under each of the Level One/Parent nodes.

Level Two Nodes [Child Nodes]

Node Name	Coding Rule
Formation of Entrepreneurship Educational Offering	Information about how the entrepreneurship initiatives for engineering undergraduates were formed and structured.
The Entrepreneurship Educational Offering	Information about the available entrepreneurship initiatives used to educate engineering undergraduates about entrepreneurship.
The Intended Audience	Information about the groups of students that the entrepreneurship initiatives target. i.e. are they only for engineering students or do engineering students work alongside students from other schools/faculties?

Level Three Nodes [Grandchild Nodes]

Level Three/Grandchild Nodes associated with the Child Node *Formation of Entrepreneurship Educational Offering*	
Node Name	**Coding Rule**
Creation of Entrepreneurship Initiative	Information about how the entrepreneurship initiative was formed. E.g. was it an initiative that the business school created for non-business students or was it an initiative that the engineering school developed specifically for their engineering students?
Location of Entrepreneurship Faculty	Information about where the faculty members that teach in entrepreneurship initiatives to engineering undergraduates are situated. E.g. does the entrepreneurship initiative use entrepreneurship faculty based in the business school?
Location of Entrepreneurship Initiative	Information about the home base of the entrepreneurship initiative i.e. where it was housed or located. E.g. is it an initiative that is housed in the business school or is it one that is situated in the engineering school?
Location of Entrepreneurship Offering	Information about where entrepreneurship courses, or other methods of learning, were offered. E.g. is the teaching of entrepreneurship situated in the engineering school or is it in the business school?

Level Three/Grandchild Nodes associated with the Child Node *The Entrepreneurship Educational Offering*	
Node Name	**Coding Rule**
Practical Experience Offering	Information about the types of practical experiences available to engineering undergraduates that enable hands-on learning of entrepreneurship, and where these experiences were offered.
Type of Curriculum	Information about the type of curriculum used in the entrepreneurship initiatives for engineering undergraduates. The curriculum is either technologically-focused, business-focused, entrepreneurship-focused, or a combination of two or three types.
Type of Educational Offering	Information about the type of educational method used that if offered through the entrepreneurship initiative. E.g. compulsory or optional bachelor degree programmes, individual courses, minors, or certificate programmes.

Level Three/Grandchild Nodes associated with the Child Node *The Intended Audience*	
Node Name	**Coding Rule**
Target Students	Information about the types of students that the entrepreneurship initiatives engineering undergraduates participate in are designed for.

Level Four Nodes [Great-grandchild Nodes]

Level Two Node (Child Node)	Level Three Node (Grandchild Node)	Level Four Node (Great-grandchild Node)	Coding Rule
Formation of Entrepreneurship Educational Offering	Creation of Entrepreneurship Initiative	**Integration into the Engineering program**	Information showing that the entrepreneurship initiative for engineering undergraduates was integrated into the engineering degree program and its courses.
		Partnership between the Engineering and other schools at the institution	Information showing that the entrepreneurship initiative for engineering undergraduates was created and developed by a partnership between the engineering school and other schools at the institution.
		Partnership between the Engineering school and external organisations	Information showing that the entrepreneurship initiative for engineering undergraduates was created and developed by a partnership between the engineering school at the institution and organisations external from the institution.
		The Business and Engineering Schools	Information showing that the entrepreneurship initiative for engineering undergraduates resulted from a collaboration between the business and engineering schools.
		The Business School	Information showing that the entrepreneurship initiative for engineering undergraduates was created and developed by the business school.
		The Engineering School	Information showing that the entrepreneurship initiative for engineering undergraduates was created and developed by the engineering school.

Formation of Entrepreneurship Educational Offering	Creation of Entrepreneurship Initiative	**The Institution**	Information showing that the entrepreneurship initiative that engineering undergraduates participated in was developed for the entire undergraduate student body, regardless of major.
	Location of Entrepreneurship Faculty	**Business and Engineering School Faculty**	Information showing that entrepreneurship is taught to engineering undergraduates by faculty members from both the business and engineering schools.
		Business School Faculty	Information showing that entrepreneurship is taught to engineering undergraduates by faculty members from the business school.
		Engineering School Faculty	Information showing that entrepreneurship is taught to engineering undergraduates by faculty members from the engineering school.
		Entrepreneurship School Faculty	Information showing that entrepreneurship is taught to engineering undergraduates by faculty members from a freestanding entrepreneurship school or centre.
	Location of Entrepreneurship Initiative	**Entrepreneurship School**	Information showing that the entrepreneurship initiative that engineering undergraduates participate in was housed in a freestanding entrepreneurship school or centre.
		The Business and Engineering Schools	Information showing that the entrepreneurship initiative that engineering undergraduates participate in was housed in both the business and engineering schools.
		The Business School	Information showing that the entrepreneurship initiative that engineering undergraduates participate in was housed in the business school.

Formation of Entrepreneurship Educational Offering	Location of Entrepreneurship Initiative	**The Engineering School**	Information showing that the entrepreneurship initiative that engineering undergraduates participate in was housed in the engineering school.
	Location of Entrepreneurship Offering	**Entrepreneurship School**	Information showing that entrepreneurship is taught to engineering undergraduates in a freestanding entrepreneurship school or centre.
		The Business and Engineering Schools	Information showing that entrepreneurship is taught to engineering undergraduates in both the business and engineering schools.
		The Business School	Information showing that entrepreneurship is taught to engineering undergraduates in the business school.
		The Engineering School	Information showing that entrepreneurship is taught to engineering undergraduates in the engineering school.

Level Two Node (Child Node)	Level Three Node (Grandchild Node)	Level Four Node (Great-grandchild Node)	Coding Rule
The Entrepreneurship Educational Offering	Practical Experience Offering	**Type of practical experience offered**	Information about the practical experience (co-curricular and extra-curricular activities) in entrepreneurship that engineering undergraduates could participate in.
		Location of practical experience offered	Information about where the practical experience that engineering undergraduates could participate in was situated/housed.
	Type of Curriculum	**Business-Focused Curriculum**	Information that showed that the entrepreneurship initiative followed a business-focused curriculum.
		Business-Focused and Entrepreneurship-Focused Curriculum	Information that showed that entrepreneurship initiative followed both a business-focused and entrepreneurship-focused curriculum.
		Entrepreneurship-Focused Curriculum	Information that showed that entrepreneurship initiatives followed an entrepreneurship-focused curriculum.
		Technologically-Focused Curriculum	Information that showed that entrepreneurship initiatives followed a technologically-focused curriculum.
		Technologically-Focused and Business-Focused Curriculum	Information that showed that entrepreneurship initiatives followed both a business-focused and a technologically-focused curriculum.
		Technologically-Focused, Business-Focused, and Entrepreneurship-Focused Curriculum	Information that showed that entrepreneurship initiatives followed a combination of a technologically-focused, business-focused, and an entrepreneurship-focused curriculum.
		Technologically-Focused and Entrepreneurship-Focused Curriculum	Information that showed that entrepreneurship initiatives followed both an entrepreneurship-focused and a technologically-focused curriculum.

The Entrepreneurship Educational Offering	Type of Educational Offering	**Entrepreneurship content in Engineering**	Information about entrepreneurship initiatives in the form of entrepreneurship content integrated into the engineering curriculum, and therefore engineering courses.
		Entrepreneurship programs	Information about entrepreneurship initiatives in the form of compulsory or optional entrepreneurship or entrepreneurship-related programmes that engineering undergraduates could participate in. This included bachelor degree programmes, minor programmes, or certificate programmes.
		Experiential Entrepreneurship learning	Information about entrepreneurship initiatives that were specifically focused on gaining entrepreneurial knowledge through practical learning activities as opposed to taking academic courses.
		Individual Entrepreneurship courses	Information about entrepreneurship initiatives in the form of compulsory or optional individual entrepreneurship or entrepreneurship related programmes that engineering undergraduates could participate in. These courses are either stand-alone courses or those included in, for example, engineering degrees, double-degrees combining engineering and business, or minors/certificate programmes in business or management

Level Two Node (Child Node)	Level Three Node (Grandchild Node)	Level Four Node (Great-grandchild Node)	Coding Rule
The Intended Audience	Target Students	**Engineering and Business Students**	Information showing that the entrepreneurship initiatives that engineering undergraduates participated in were for engineering and business students only.
		Engineering Students	Information showing that the entrepreneurship initiatives that engineering undergraduates participated in were for engineering students only.
		Engineering, Business and students from some faculties	Information showing that the entrepreneurship initiatives that engineering undergraduates participated in were for engineering students, business students and students from a selected set of schools at the academic institution only.
		Non-Business Students	Information showing that the entrepreneurship initiatives that engineering undergraduates participated in were for all undergraduate students except those studying in the business school.
		Some Engineering Students	Information showing that the entrepreneurship initiatives that engineering undergraduates participated in were for engineering students following some (but not all) of the engineering majors.
		Some engineering students plus business students	Information showing that the entrepreneurship initiatives that engineering undergraduates participated in were for engineering students following some (but not all) of the engineering majors plus students studying in the business school.
		Undergraduate Students	Information showing that the entrepreneurship initiatives that engineering undergraduates participated in were for all undergraduate students at the institution, regardless of the major being pursued.

Appendix Four: Questions posed in Phase Three

The Questionnaire was divided into four sections, each section consisting of varying numbers of questions:

- A: Demographics
- B: How Entrepreneurship is combined with Engineering
- C: The Structure of the Entrepreneurship Initiatives
- D: The Content of the Entrepreneurship Initiatives

A: Demographics

Questionnaire Question Number	Question
1	What is the name of your university/institution?
2	What is the name of the faculty/school in which your engineering program is located?
3	Does your university/institution offer specific programs that are designed to develop entrepreneurship competencies in your engineering undergraduates?
4	Which of the following engineering majors does your university/institution offer? (Please select all that apply) o Aeronautics and Astronautics Engineering o Agricultural and Biological Engineering o Architectural Engineering o Biomedical Engineering o Biomolecular Engineering o Chemical Engineering o Civil Engineering o Computer Engineering o Computer Science o Construction Engineering o Electrical Engineering o Environmental/Ecological Engineering o Industrial/Systems Engineering o Interdisciplinary Engineering o Manufacturing Engineering o Materials/Materials Science Engineering o Mechanical Engineering o Multidisciplinary Engineering o Nuclear Engineering o Textile Engineering o Other (please specify)

B: How Entrepreneurship is combined with Engineering

Questionnaire Question Number	Question
7	The entrepreneurship education initiatives for engineering undergraduates is: • a core requirement • an optional component/elective Comment: *[** Only one option could be selected]*
8	Is your university/institution a member of, or affiliated with, any entrepreneurship-related networks, foundations, or initiatives? Please list.
9	Do you agree with the following statement: "Entrepreneurship is well supported at my university/institution"? (For example, does your university/college support the program by investing a lot of resources? does your university/institution consider it valuable for the students to acquire entrepreneurship abilities? does your university/institution actively promote participation in entrepreneurship programs?) Please explain your choice.

C: The Structure of the Entrepreneurship Initiatives

Questionnaire Question Number	Question
5	Our entrepreneurship initiatives for engineering undergraduate students are the result of: • funding from the school of business to educate non-business students about entrepreneurship • funding given to the school of business by the school of engineering to provide entrepreneurship education to engineering students • funding from the school of engineering to provide entrepreneurship education for their students, with entrepreneurship initiatives being housed in the school of engineering • a desire for knowledge and ideas to be shared between the business and engineering schools, with entrepreneurship initiatives being housed in the school of engineering • a desire for knowledge and ideas to be shared between the business and engineering schools, with entrepreneurship initiatives being housed in the school of business

	• a desire for active collaboration to occur among the business school, engineering school, and some of the other schools in the university/institution • a desire for active collaboration to occur among the engineering school and some of the other schools in the university/institution (but NOT the business school) • a university-wide or institution-wide initiative • a partnership with the home institution and an external organization and/or another university/institution • Other (please specify) *[** Only one option could be selected]*
6	Our entrepreneurship initiatives for engineering students are located in: • the engineering school • the business school • both the engineering and business schools • a freestanding entrepreneurship school/centre • Other (please specify) *[** Only one option could be selected]*
10	In our university/institution, we offer: • an entrepreneurial engineering undergraduate program • an entrepreneurship class or component incorporated into undergraduate engineering programs • Other (please specify) *[** Only one option could be selected]*
11	Please provide the name(s) and a brief overall description of your entrepreneurship program(s) for your engineering undergraduates.
12	What is the duration of the entrepreneurship program offered to engineering students? (Please select all that apply) o Year-long program o Semester-long program o Short intensive course (please state in terms of days, weeks, or months)
14	In our entrepreneurship initiatives, our engineering undergraduates experience: • academic courses only • academic courses plus extra- and/or co-curricular activities • academic courses plus associated practical learning (e.g. internships, class projects, senior projects) and extra- and/or co-curricular • activities • academic courses plus associated practical learning (e.g. internships, class projects, senior projects) only • practical learning only • practical learning plus extra- and/or co-curricular activities • Other (please specify) *[** Only one option could be selected]*

15	The entrepreneurship initiatives that our engineering undergraduates participate in are for: • engineering students only • engineering and business students only • engineering and non-business students only • engineering, business, and other non-business students • Other (please specify) *[** Only one option could be selected]*
18	Who typically teaches the entrepreneurship courses in your program? (Please select all that apply) o Engineering Academics o Business Academics o Engineering Grad Students o Business Grad Students o Practicing/Experienced Entrepreneurs o Other (please specify)
19	In which school is your entrepreneurship teaching faculty located? • Engineering school • Business school • Both Engineering and Business schools • Freestanding Entrepreneurship school/centre • Other (please specify) *[** Only one option could be selected]*
21	Where are the entrepreneurship courses for engineering students delivered? • Engineering school • Business school • Both Engineering and Business schools • Freestanding Entrepreneurship school/centre • Other (please specify) *[** Only one option could be selected]*

D: The Content of the Entrepreneurship Initiatives

Questionnaire Question Number	Question
13	What are the objectives of the entrepreneurship program for engineering undergraduates?
16	The following is/are learning outcomes or objectives of our entrepreneurship program for engineering undergraduates: (Please select all that apply): o LEARNING TO BECOME AN ENTERPRISING INDIVIDUAL - The aim of this is to make individuals more entrepreneurial by first working on the entrepreneurial mindset and then on the demonstration of entrepreneurial actions o LEARNING TO BECOME AN ENTREPRENEUR - The aim is to create entrepreneurs and teach individuals how to, for example, start a business, engage in some type of entrepreneurial project, or learn about various entrepreneurial situations and contexts o LEARNING TO BECOME AN ACADEMIC - The aim is to help individuals to become entrepreneurship teachers and/or researchers
17	To what extent does your entrepreneurship program emphasize each of the following? (Please indicate the level of emphasis): No emphasis Some emphasis Moderate emphasis Major emphasis Significant emphasis o OPPORTUNITY RECOGNITION - The capacity to perceive changed conditions or overlooked possibilities in the environment that represent potential sources of profit or return to a venture o OPPORTUNITY ASSESSMENT - The ability to evaluate the content structure of opportunities to accurately determine their relative attractiveness o RISK MANAGEMENT/MITIGATION - The taking of actions that reduce the probability of a risk occurring or reduce the potential impact if the risk were to occur o CONVEYING A COMPELLING VISION - The ability to conceive an image of a future organizational state and to articulate that image in a manner that empowers followers to enact it o TENACITY/PERSEVERANCE - The ability to sustain goal-directed action and energy when confronting difficulties and obstacles that impede goal achievement o CREATIVE PROBLEM SOLVING/IMAGINATIVENESS - The ability to relate previously unrelated objects or variables to produce novel and appropriate or useful outcomes o RESOURCE LEVERAGING - Skills at accessing resources one does not necessarily own or control to accomplish personal ends

	- GUERRILLA SKILLS – The capacity to take advantage of one's surroundings, employ unconventional, low-cost tactics not recognised by others, and do more with less - VALUE CREATION - Capabilities of developing new products, services, and/or business models that generate revenues exceeding their costs and produce sufficient user benefits to bring about a fair return - MAINTAIN FOCUS YET ADAPT - The ability to balance an emphasis on goal achievement and the strategic direction of the organization while addressing the need to identify and pursue actions to improve the fit between an organization and the environment - RESILIENCE - The ability to cope with stresses and disturbances such that one remains well, recovers, or even thrives in the face of adversity - SELF-EFFICACY - The ability to maintain a sense of self-confidence regarding one's ability to accomplish a particular task or attain a level of performance - BUILDING AND USING NETWORKS – Social interaction skills that enable an individual to establish, develop, and maintain sets of relationships with others who assist them in advancing their work or career
22	The curriculum of our university/institution's entrepreneurship program for engineering students is: - Technologically-oriented - Business-oriented - Other (please specify) *[** Only one option could be selected]*
23	The curriculum of our university/institution's entrepreneurship program for engineering students was developed: - by the engineering school - by the business school - through a collaboration between the business and engineering schools - through a collaboration between a number of schools - by a freestanding entrepreneurship school/centre - by the university/institution - Other (please specify) *[** Only one option could be selected]*
24	In our university/institution, we provide opportunities for our engineering students to… (Please select all that apply) - Take an entrepreneurship course within the Faculty/School of Engineering - Intern or work for an entrepreneurial or start-up company - Conduct market research and analysis for a new product or technology - Develop a product or technology for a real client/customer - Give an "elevator pitch" or presentation to a panel of judges about a product or business idea - Be involved in patenting a technology or protecting intellectual property - Be involved in entrepreneurship- or business-related student organizations

	o Write a business plan o Participate in an entrepreneurship-related competition (e.g. product development, business plan) o Participate in entrepreneurship-related workshops (extra-curricular, non-credit) o Other (please specify)
25	What entrepreneurship co-curricular and/or extra-curricular activities do you offer to your engineering undergraduates?
28	After graduation, we encourage our engineering students to… (Please select all that apply) o Start their own business or be self-employed o Work for a small business or start-up company o Work for a medium- or large-size business o Work for a social enterprise o Work for a non-profit organization o Attend graduate/professional school o Other (please specify)
29	After graduation, our university/institution offers alumni the following: (Please select all that apply) o Access to a university venture fund o Access to a university alumni business angel group o Access to university technology transfer opportunities o Business networking opportunities o Other (please specify)

Appendix Five: Comparative Summary of the models of the Entrepreneurial Engineering Education (EEE) Typology

The Entrepreneurial Engineering Education (EEE) Typology					
Components of the Models	**Models**				
	Model 1: ***Business School*** **model**	**Model 2:** ***Engineering School*** **model**	**Model 3:** ***Multi-School*** **model**	**Model 4:** ***External Partnership*** **model**	**Model 5:** ***Institution*** **model**
Distinguishing characteristics	Entrepreneurship initiatives developed either solely by the business school or by the business school in collaboration with another school, primarily the engineering school; with the initiatives housed in the business school.	Entrepreneurship initiatives developed either solely by the engineering school, or by the engineering school in collaboration with the business school; with the initiatives primarily housed in the engineering school.	Entrepreneurship initiatives resulting from a partnership involving the engineering school, the business school, and one or more of the other schools at the academic institution; with some partnerships excluding the business school.	Entrepreneurship initiatives developed from a partnership involving either the engineering school or both the engineering and business schools of an institution and external organisations or other tertiary-level academic institutions.	Entrepreneurship initiatives developed by academic institutions to educate all students at an academic institution, regardless of major, about entrepreneurship.
Countries the model is present within	Australia Canada New Zealand The United States	Australia Canada New Zealand The United Kingdom The United States	The United States	Canada The United States	Australia The United Kingdom The United States
The Objectives of entrepreneurship initiatives	*To understand entrepreneurship *To develop the entrepreneurial mindset *To provide the skills needed to be and act entrepreneurially *To provide practical entrepreneurial experience	*To understand entrepreneurship *To develop the entrepreneurial mindset *To provide the skills needed to be and act entrepreneurially *To provide practical entrepreneurial experience	*To understand entrepreneurship *To develop the entrepreneurial mindset *To provide the skills needed to be and act entrepreneurially *To provide practical entrepreneurial experience	*To understand entrepreneurship *To develop the entrepreneurial mindset *To provide the skills needed to be and act entrepreneurially *To provide practical entrepreneurial experience	*To understand entrepreneurship *To develop the entrepreneurial mindset *To provide the skills needed to be and act entrepreneurially *To provide practical entrepreneurial experience

Types of educational programmes offered in the entrepreneurship initiatives	*short entrepreneurship programmes *entrepreneurial experiential or practical learning programmes *individual entrepreneurship courses *entrepreneurship-based bachelor degree programmes	*short entrepreneurship programmes *entrepreneurial experiential or practical learning programmes *individual entrepreneurship courses *entrepreneurship-based bachelor degree programmes *individual entrepreneurial engineering courses and programmes	*short entrepreneurship programmes *entrepreneurial experiential or practical learning programmes	*short entrepreneurship programmes *entrepreneurial experiential or practical learning programmes *individual entrepreneurship courses *entrepreneurship-based bachelor degree programmes *individual entrepreneurial engineering courses and programmes	*short entrepreneurship programmes *entrepreneurial experiential or practical learning programmes *individual entrepreneurship courses *entrepreneurship-based bachelor degree programmes
Types of curriculum used in the entrepreneurship initiatives	One, or combinations of two or three, of the following: *Business-focused *Technological-focused *Entrepreneurship-focused	One, or combinations of two or three, of the following: *Business-focused *Technological-focused *Entrepreneurship-focused	One, or combinations of two or three, of the following: *Business-focused *Technological-focused *Entrepreneurship-focused	One, or combinations of two or three, of the following: *Business-focused *Technological-focused *Entrepreneurship-focused	One, or combinations of two or three, of the following: *Business-focused *Technological-focused *Entrepreneurship-focused
The locations where entrepreneurship courses are taught	*Business school (primary location) *Engineering school *Entrepreneurship school *Other non-business schools	*Engineering school (primary location – Can, U.K., U.S) *Business school (primary location – Aus & N.Z) *Campus wide (engineering-only institutions) *Entrepreneurship school *Engineering school and other schools	*The schools belonging to the partnership (primary location) *Business school *schools other than the business and engineering schools *Engineering school *Business, Engineering, and other schools *Entrepreneurship school	*Engineering school (primary location) *Engineering and Business schools *Business school	*Entrepreneurship school (primary location) *Engineering and Business schools *Various/some schools at the institution *Business school

The Target Students	*All undergraduate students (primary group) *Engineering and other Non-business undergraduates *Engineering and Business undergraduates *Engineering undergraduates only	*Engineering undergraduates only (primary group) *Engineering and Business undergraduates *Engineering and other science and technical undergraduates *All undergraduate students *Engineering undergraduates following some engineering majors	*All undergraduate students (primary group) *Engineering and other Non-business undergraduates *Undergraduates from the schools belonging to the partnership	*Engineering undergraduates only (primary group) *All undergraduate students * Non-business undergraduates *Engineering and Business undergraduates *Engineering and other science and technical undergraduates	*All undergraduate students
The main practical experiences offered in entrepreneurship initiatives	*Business creation activities (primary type) *New technology/new product creation activities	*Business creation activities (primary type – Aus, Can, & U.K.) *New technology/new product creation activities (primary type – NZ & U.S.)	*Business creation activities (primary type) *New technology/new product creation activities	*New technology/new product creation activities (primary type) *Business creation activities	*Business creation activities (primary type) *New technology/new product creation activities
Entrepreneurship competencies emphasised in entrepreneurship initiatives **(from most emphasised (me) to least emphasised (le))**	*Tenacity/Perseverance (me) *Creative Problem Solving/Imaginativeness (me) *Opportunity Assessment *Value Creation *Building and Using Networks *Opportunity Recognition *Conveying a Compelling Vision *Resource Leveraging	*Value Creation (me) *Creative Problem Solving/Imaginativeness *Conveying a Compelling Vision *Tenacity/Perseverance *Maintain Focus yet Adapt * Resilience *Building and Using Networks *Self-Efficacy *Resource Leveraging *Opportunity Assessment	*Opportunity Assessment (me) *Creative Problem Solving/Imaginativeness (me) *Risk Management/Mitigation *Conveying a Compelling Vision *Tenacity/Perseverance *Value Creation *Self-Efficacy *Building and Using Networks	*Creative Problem Solving/Imaginativeness (me) *Opportunity Recognition *Conveying a Compelling Vision *Tenacity/Perseverance *Self-Efficacy *Maintain Focus yet Adapt *Building and Using Networks *Opportunity Assessment	*Creative Problem Solving/Imaginativeness (me) *Resource Leveraging *Opportunity Recognition *Opportunity Assessment *Tenacity/Perseverance *Value Creation *Self-Efficacy *Building and Using Networks *Risk Management/Mitigation

	*Risk Management/Mitigation *Maintain Focus yet Adapt *Self-Efficacy *Resilience (le)	*Guerrilla Skills *Opportunity Recognition *Risk Management/Mitigation (le)	*Opportunity Recognition (le) *Resource Leveraging (le) *Guerrilla Skills (le) *Maintain Focus yet Adapt (le) * Resilience (le)	* Resilience *Resource Leveraging *Guerrilla Skills *Risk Management/Mitigation (le)	*Conveying a Compelling Vision *Guerrilla Skills *Maintain Focus yet Adapt * Resilience (le)
The opportunities experienced in entrepreneurship initiatives (from most commonly offered (mc) to least commonly offered (lc))	*Develop a product or technology for a real client/customer (mc) *Be involved in entrepreneurship- or business-related student organisations (mc) *Write a business plan (mc) *Participate in an entrepreneurship-related competition (mc) *Participate in entrepreneurship-related workshops (mc) *Intern or work for an entrepreneurial or start-up company *Give an "elevator pitch" or presentation to a panel of judges about a product or business idea *Be involved in patenting a technology or protecting intellectual property *Take an entrepreneurship course	*Take an entrepreneurship course within the Faculty/School of Engineering (mc) *Develop a product or technology for a real client/customer *Give an "elevator pitch" or presentation to a panel of judges about a product or business idea *Write a business plan *Participate in an entrepreneurship-related competition *Be involved in entrepreneurship- or business-related student organisations *Participate in entrepreneurship-related workshops *Intern or work for an entrepreneurial or start-up company *Conduct market research and analysis for	*Intern or work for an entrepreneurial or start-up company (mc) *Develop a product or technology for a real client/customer (mc) *Write a business plan (mc) *Take an entrepreneurship course within the Faculty/School of Engineering *Be involved in patenting a technology or protecting intellectual property *Be involved in entrepreneurship- or business-related student organisations *Give an "elevator pitch" or presentation to a panel of judges about a product or business idea *Participate in an entrepreneurship-related competition	*Give an "elevator pitch" or presentation to a panel of judges about a product or business idea (mc) *Be involved in entrepreneurship- or business-related student organisations (mc) *Participate in entrepreneurship-related workshops (mc) *Participate in an entrepreneurship-related competition (mc) *Take an entrepreneurship course within the Faculty/School of Engineering *Develop a product or technology for a real client/customer *Intern or work for an entrepreneurial or start-up company *Conduct market research and analysis for	*Intern or work for an entrepreneurial or start-up company (mc) *Give an "elevator pitch" or presentation to a panel of judges about a product or business idea (mc) *Be involved in entrepreneurship- or business-related student organisations (mc) *Be involved in entrepreneurship- or business-related student organisations (mc) *Participate in an entrepreneurship-related competition (mc) *Participate in entrepreneurship-related workshops (mc) *Conduct market research and analysis for a new product or technology

	within the Faculty/School of Engineering (lc) *Conduct market research and analysis for a new product or technology (lc)	a new product or technology *Be involved in patenting a technology or protecting intellectual property (lc)	*Conduct market research and analysis for a new product or technology (lc) *Participate in entrepreneurship-related workshops (lc)	a new product or technology *Be involved in patenting a technology or protecting intellectual property *Write a business plan (lc)	*Develop a product or technology for a real client/customer *Write a business plan *Take an entrepreneurship course within the Faculty/School of Engineering (lc)
The Outcomes of entrepreneurship initiatives	Students were educated to become: *Entrepreneurs (primary) *Enterprising Individuals Students were educated to do the following: *Start their own business or be self-employed (primary) *Attend graduate/professional school (primary) *Work for a small business or start-up company *Work for a medium- or large-size business *Work for a social enterprise *Work for a non-profit organisation	Students were educated to become: *Enterprising Individuals (primary) *Entrepreneurs *Entrepreneurship Academics Students were educated to do the following: *Start their own business or be self-employed (primary) *Work for a small business or start-up company (primary) *Work for a medium- or large-size business (primary) *Attend graduate/professional school *Work for a social enterprise *Work for a non-profit organisation *Consider an option of their choice	Students were educated to become: *Enterprising Individuals (primary) *Entrepreneurs (primary) *Entrepreneurship Academics Students were educated to do the following: *Start their own business or be self-employed (primary) *Work for a small business or start-up company *Attend graduate/professional school *Work for a medium- or large-size business *Work for a social enterprise *Work for a non-profit organisation	Students were educated to become: *Enterprising Individuals (primary) *Entrepreneurs Students were educated to do the following: *Work for a small business or start-up company (primary) *Start their own business or be self-employed *Work for a medium- or large-size business *Attend graduate/professional school *Work for a social enterprise *Work for a non-profit organisation	Students were educated to become: *Enterprising Individuals (primary) *Entrepreneurs *Entrepreneurship Academics Students were educated to do the following: *Start their own business or be self-employed (primary) *Work for a small business or start-up company (primary) *Work for a medium- or large-size business (primary) *Attend graduate/professional school (primary) *Work for a social enterprise *Work for a non-profit organisation

Appendix Six: Published Paper

The Creation of Entrepreneurial Engineers:
A Re-evaluation of the Standish-Kuon and Rice (2002) Typology and the Emergence of the Entrepreneurial Engineering Education (EEE) Typology

Niyan K.O. Fraser[A], Morgan P. Miles[B], Megan Woods[A], Gemma K. Lewis[A]
[A]University of Tasmania, [B]University of Canterbury

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